SENEGAL RIVER BASIN

HEALTH MASTER PLAN STUDY

WASH Field Report No. 453
December 1994

WATER AND SANITATION for HEALTH PROJECT

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Senegal River Basin Health Master Plan Study

Prepared for the USAID Mission to Senegal
U.S. Agency for International Development
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by

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Senegal River Basin Health Master Plan Study

ERRATA

P. xix, paragraph 6, line 1: "The Senegal River rises in Guinea..."

P. 21, paragraph 4, lines 4-5: "Given the decrease in rainfalls in the Lower Valley..."

P. 35, Current Findings/Epidemiological Survey, paragraph 2, line 1: "In the Delta, three schools on the Mauritanian bank of the river (Figures 12 and 14)..."

P. 57, Figure 20: Green line = St. Louis, red line = Dagana

P. 68, fourth full paragraph, line 3: "...to allow farmers to harvest a normal crop (Figure 19 and Figure 25)."

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Jan Rozendaal is a biologist specializing in the investigation and control of malaria. He has a Ph.D. in epidemiology and entomology from the State University, Leiden, Netherlands. He has served as malaria adviser to USAID in Pakistan and as associate scientist for the World Health Organization in Geneva, and prepared a malaria research and control project in Pakistan for the European Community.

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National Working Groups from Ministries of Health

Mali Working Group	*Mauritania Working Group*	*Senegal Working Group*
Fode Boundy	Abdellahi Ould Nem	Youssoupha Camara
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Mamadou Kane	Mohamed Bechir Aounen	
Lasseni Konate	Yelsen Benani	
Mariam Maiga		
Djibril Semega		
~~Ousmane Toure~~		

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Ibrahima Deme — veterinarian
Khadijatou Deng — biologist
Aline Kane — parasitologist
Coudy Ly — sociologist
Faye Malick — entomologist
Foekge Stelma — physician
Ibrahima Toure — nurse

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Finally, because this report is large, in two languages, and includes extensive graphics, its compilation and production have been a major undertaking. We are indebted to Ms. Carole Thompson for coordinating the effort and admire her ability to survive chaos with grace and composure. Thanks are also due to Ms. Betsy Reddaway, Publications Manager for the WASH Project, and to Peggy Greenfield/DESIGN and March Day, who prepared the photo layouts.

Eugene P. Brantly
WASH Task Manager

Acronyms

CSE	*Centre de Suivi Ecologique*
CSS	Senegalese Sugar Company
DDC	Division of Development and Cooperation
DRASS	Directorate of Health and Social Affairs
ERM	Environmental Resources Management
INRSP	*Institut National de Recherche en Sante Publique*
MAS	Mission for Development of the Senegal River
MEFS	Mission for Studies of the Senegal River
MOH	Ministry of Health
NGOs	Non-Governmental Organizations
OCP	Onchocerciasis Control Program
OERS	Organization of Riparian States of the Senegal River
OMVS	*Organisation pour la Mise en Valeur du Fleuve Sénégal*
ORS	Oral Rehydration Salts
PDRG	Master Plan of the Left Bank
PDRH	Human Resources Development Project
PEEM	Panel of Experts on Environmental Management
PEV	Expanded Vaccination Program
PHC	Primary Health Care
SIG	*Systeme d'Informations a fin de la Gestion*
SIGRES	*Systeme d'Information Geographique sur les Ressources en Eau du Sénégal*
SONEES	*Société Nationale d'Exploitation des Eaux du Sénégal*
UN	United Nations
UNDP	United Nations Development Programme
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
WASH	Water and Sanitation for Health
WHO	World Health Organization

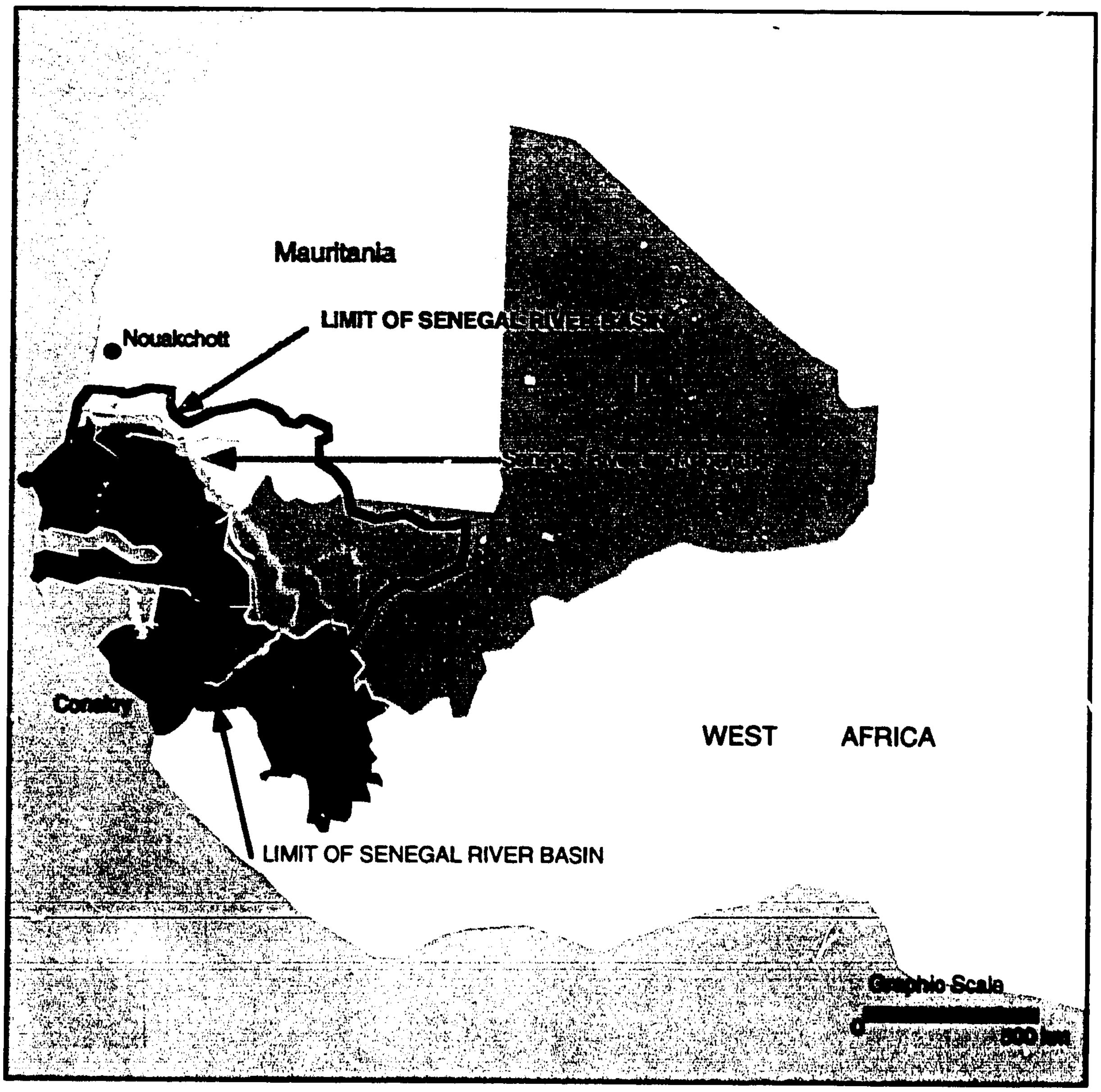


Figure 1: Senegal River and Countries within the River Basin

Preface

This study examines current health conditions in the Senegal River Basin that are directly related to development of the river's water resources. The study was commissioned by the U.S. Agency for International Development's Mission to Senegal, at the request of the Senegal River Development Authority (Organisation pour la Mise en Valeur du Fleuve Senegal, or OMVS).

The study involved field work in the spring and summer of 1994 to collect original epidemiological, biological, and social data, primarily in Mauritania and Mali; careful review of the results from previous epidemiological and sociological studies by other organizations; and field evaluation of the current status of water and sanitation infrastructure and public health systems. New data were developed by WASH field teams and also by country working groups that conducted original research commissioned by WASH.

Although most of the findings reported herein derive from the WASH team's original work, the conclusions and recommendations also rest on a base of twenty years of previous experience and documentation. The team's work was greatly facilitated by existing information on health and water resources in the Senegal River Basin, the product of two decades of development and research. The authors recognize their reliance on the work of many predecessors.

The draft version of this report was reviewed and discussed by OMVS representatives and members of the three country working groups in a three-day conference held in St. Louis, Senegal in September, 1994. The reviewers endorsed the study's findings and the team's recommendations. They also requested certain revisions to the report, all of which have been addressed.

Volume 1 of the report summarizes the team's findings and Volume 2 presents the team's conclusions and recommendations to the OMVS. The original draft field reports, which present more detailed information, have not been included as annexes but are available from WASH on request.

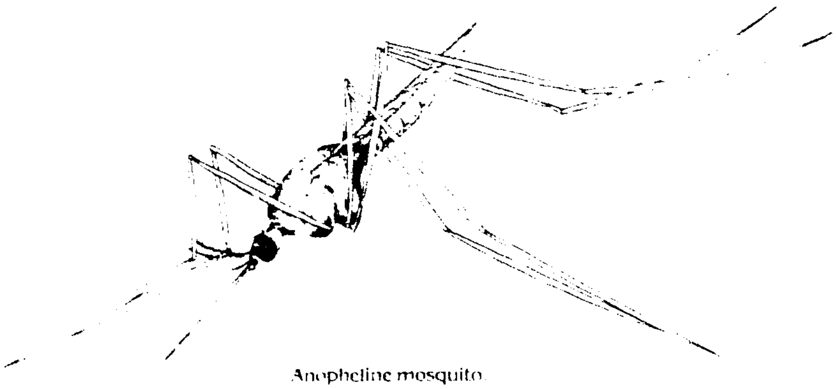
The Senegal River rises in The Gambia, runs through western Mali, and flows west to form the border between Senegal and Mauritania (Figure 1). During the past decade, there have been profound changes in the ecology of the Senegal River Basin and the social conditions of its inhabitants. These changes have been accompanied by dramatic increases in the prevalence of water-related diseases in the basin's population (Figure 2) and major, detrimental modifications of environmental conditions. Some of these changes are attributable to the activities of the OMVS -- the construction of the dams at Manantali and Diama, and the operation of these dams to regulate water levels in the reservoirs and river. Through the construction of dams, dikes, and irrigated perimeter areas, OMVS has become a major actor in the river basin and its water management activities have an ongoing and profound effect on the basin's entire ecological system (Figure 3). OMVS, however, is not solely responsible for all of the changes in the basin and their impacts on the ecology and human population. Other changes have also played a large part, including:

- the rapid development of large industrial and commercial agricultural projects;
- the migration of 50,000 people in the Lower Valley to provide labor for these projects;
- increased intensity of rice cultivation in response to national agricultural policies;
- the relocation of 10,000 people in the upper basin before filling the Manantali reservoir; and
- the inadequate development of water and sanitation infrastructure and public health facilities in the river basin regions.

The OMVS was created to promote the integrated development of the Senegal River Basin. Its creation was, in part, a recognition of the basin's fragile ecology and precarious human conditions, dramatically demonstrated by the droughts and famine of the 1970s and 1980s. The physical infrastructure that OMVS needs in order to manage water quantity in the basin -- and, thereby, to promote integrated development and improve the well-being of people in the basin, as well as those in the region's urban centers -- is now in place. Given OMVS' strategic influence in the basin and its international structure, the organization has an enormous potential for promoting ecological stability and human prosperity in the basin. The problems it faces are not unique; other river basin authorities in many parts of the world, and especially in Africa, have discovered that they must deal with a complex and interrelated web of environmental factors, modes of economic production, and demographic and social change. These factors present enormous challenges to the wise management of water resources.

By requesting this study and paying attention to its results, OMVS has demonstrated its interest in the health impacts of its activities and its potential role in improving public health conditions in the basin. During the next few years, before the generation of electricity begins at Manantali Dam, the OMVS has an unusual opportunity to focus on developing economical and sustainable methods of water management that balance the needs of energy production, agriculture, and public health. Some of the basin's most important health problems can be substantially improved by controlling disease vectors through water level fluctuations, which may be accomplished by the coordinated operation of Manantali and Diama dams. The OMVS also has key roles to play in facilitating better coordination among public health agencies in the basin and in promoting the collection, analysis, and use of information on water-related health problems.

The recommendations presented in this report are intended to strengthen the OMVS and improve its ability to meet its development goals, which include improving the health and well-being of basin residents. WASH and the authors of this report are pleased to have had the opportunity to conduct the study and, hopefully, to make some contribution that will help OMVS improve the lives of people who rely on the Senegal River. We thank the OMVS and USAID/Dakar for this opportunity.



Anopheline mosquito

MALARIA

The most common of the tropical diseases related to water malaria is transmitted throughout the tropics by anopheline mosquitoes which are often found infesting reservoirs irrigation canals and drains. Due to resistance to insecticides and drugs prevention by environmental modi fication is becoming a necessity in water resource developments. These environmental control measures are best implemented in the design stages of a project.

Shells of planorbid snails

BILHARZIA

Bilharzia is a parasitic disease transmitted in a complex cycle by fresh water snails. an infection closely linked with irrigation and classically associated with the Nile River. It is also found however in the Caribbean area and Brazil, in China, the Philippines and the Middle East. The disease is also known academically as schistosomiasis.

Blackfly

RIVER BLINDNESS

This disease prevalent in Africa and tropical America, is spread through the bite of the blackfly. The biting blackfly breeds in rapids or white-water on spillways and water control structures. and is responsible for impeding agricultural development in much of West Africa. The disease is also known as onchocerciasis to parasitologists.

Major Diseases Related to Water Resource Projects

BLUE NILE ASSOCIATES P.O. BOX 542 FOXBORO, MASSACHUSETTS 02035 U.S.A.

Figure 2: Major Diseases Related to Water Resource Projects

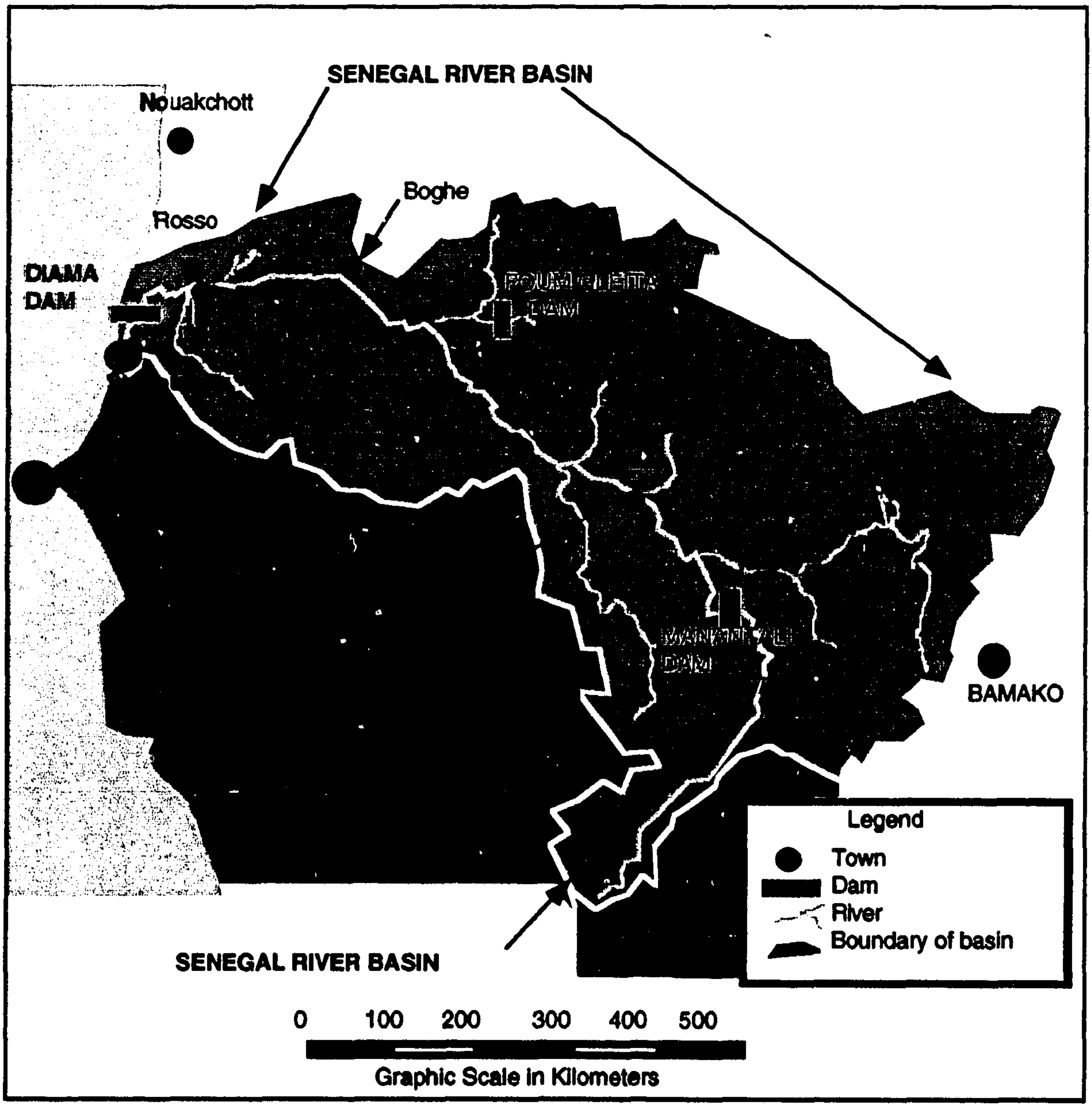


Figure 3: Senegal River Basin of West Africa

Executive Summary

FINDINGS

A rapid assessment of health information, and probes into health conditions in the Senegal River Basin in 1994, revealed important changes in water-associated diseases during the previous decade; the changes were largely but not solely related to river regulation by the OMVS. Some changes were positive; some were negative.

Improvements in Water Resources

The health and ecological effects of river regulation by the OMVS have to be seen in the overall context of their decade of improvements in the use of the basin's water resources. The barrier dam at Diama has prevented the annual intrusion of salt water into the Lower Valley, making irrigated agriculture possible throughout the year. Storage of the annual flood by Manantali Dam has allowed the OMVS to maintain Diama Reservoir at a full and stable level, and to raise the levels of Lake Guiers and Lake Rkiz, considerably reducing costs for pumped irrigation systems around these water bodies. Because of these improvements, irrigated agriculture has become a major economic force in the valley.

Improvements in Health

In addition to the improvements in irrigation, improvements in health were observed in 1994, including a decrease in seasonal outbreaks of diarrheal diseases in the Middle Valley and a decrease in river blindness in the Upper Valley. There were also decreases in bilharzia and malaria in parts of the Middle Valley because of regulating the large and erratic annual flood. Also, a small reservoir and irrigation system on the Gorgol River in Mauritania had no bilharzia in 1994, compared to the high prevalence of the disease before construction. The most positive finding in the Upper Valley was that the rapid drawdown of the water level in Manantali Reservoir in early 1994 caused the stranding and death of most of the bilharzia snails in that reservoir.

Health Problems

Important negative health effects included an increase in bilharzia around both Diama and Manantali reservoirs and in many intensively cultivated areas in the Lower Valley, especially in the sugar cane areas around Richard-Toll in Senegal. Deficiencies in water supply and sanitation facilities around expanding agro-industrial projects in Richard-Toll have caused increased risks of cholera and other diarrheal diseases. Industrial and agricultural chemicals from this area have contaminated public water supplies, with the potential to affect supplies for St. Louis and Dakar.

Other negative effects included malnutrition, which persisted at disturbingly high levels among farm families, despite planners' assumptions about expected improvements in food availability because of irrigated agriculture. An important structural deficiency noted in the river basin was the lack of a system for information flow between health and development agencies, and the absence of coordinated programs. These deficiencies have inhibited rapid responses to epidemics and have prevented coordinated efforts to improve health in the Senegal River Basin.

Rift valley fever, which was introduced the first year the dams began storing water, persists as a risk around the reservoirs. Further epidemics of this and other lethal viral diseases transmitted by insects could recur and might affect Nouakchott, as well as population centers around the reservoirs.

Specific Findings

The following specific observations were made on health, either through the review of existing reports or from epidemiological data collected during our study:

Bilharzia

- In 1990, a new and rapidly expanding focus of severe intestinal bilharzia had been found in the sugar cane irrigation system of the agro-businesses in Richard-Toll (**Figure 4**).

- By 1994, this disease had spread to most of the shoreline of Diama Reservoir, including Lake Guiers in Senegal. The snails that transmit intestinal bilharzia were also found in the canals leading to Lake Rkiz in Mauritania.

- Around Manantali Reservoir in Mali, high prevalence of urinary and intestinal bilharzia were found among the fishing communities in 1994.

- Urinary bilharzia was originally widespread in the valley before 1988. It increased near most new and intensive irrigation projects by 1994, with the exception of the Gorgol Project in Mauritania and former rice irrigation systems near Podor in Senegal.

Diarrheal Diseases and Water Supplies

- Increased human populations and deficient water supply facilities have increased the risk of cholera and other diarrheal diseases around Richard-Toll.

- Contamination of water supplies by various substances around Richard-Toll resulted in toxic episodes in local populations and also posed a threat to expanded drinking water supplies planned for St. Louis and Dakar.

Figure 4: Industrial and traditional activities in the middle valley. The Senegal Sugar Company on the left bank of the Senegal River at Richard Toll is the largest employer in the river valley *(a)*. In contrast, camels and herding are the major activity across the river in Mauritania *(b)*.

Figure 4: Activités industriélles et traditionnelles dans la vallée intermédiare. La Société de Sucre au Sénégal sur la rive gauche du fleuve Sénégal a Richard Toll est le plus grand employeur de la vallée *(a)*. En revanche, les chameaux et l'élevage représentent la principale activité de l'autre côté en Mauritanie *(b)*.

(a)

photos: Jobin

(b)

Paradox of Malnutrition

- Year-round availability of water has allowed many farmers in Mauritania and Senegal to become involved in irrigated agriculture. In certain locations, two rice crops are harvested each year. However, high levels of malnutrition, which existed before the expanded rice cultivation, persisted among the farm families in 1994.

- Continued malnutrition observed among farmers along the Senegal River was related to limited profitability of rice production, to poor yields, and to problems with marketing the rice (**Figure 5**). In 1994, most farmers involved in irrigated rice production were in debt, and hence were severely constrained in providing an adequate diet for their households.

Double-Cropped Rice and a Prolonged Malaria Season

- The increase in irrigation activities increased the availability of breeding sites for malaria mosquitos. Irrigation beyond the rainy season to grow a second crop of rice prolonged the breeding season of malaria mosquitos in the Middle Valley, and also prolonged the average lifespan of the adult mosquitos by increasing the local relative humidity. Malaria outbreaks reported during the winter in Boghe, Mauritania, and Podor, Senegal, were probably related to the second crop of rice in those areas.

- On the left bank in the Middle Valley, people living close to irrigated fields used mosquito nets. In combination with widespread availability of domestic animals, these nets may have been effective in diverting malaria mosquitos away from people and toward the animals.

Other Diseases

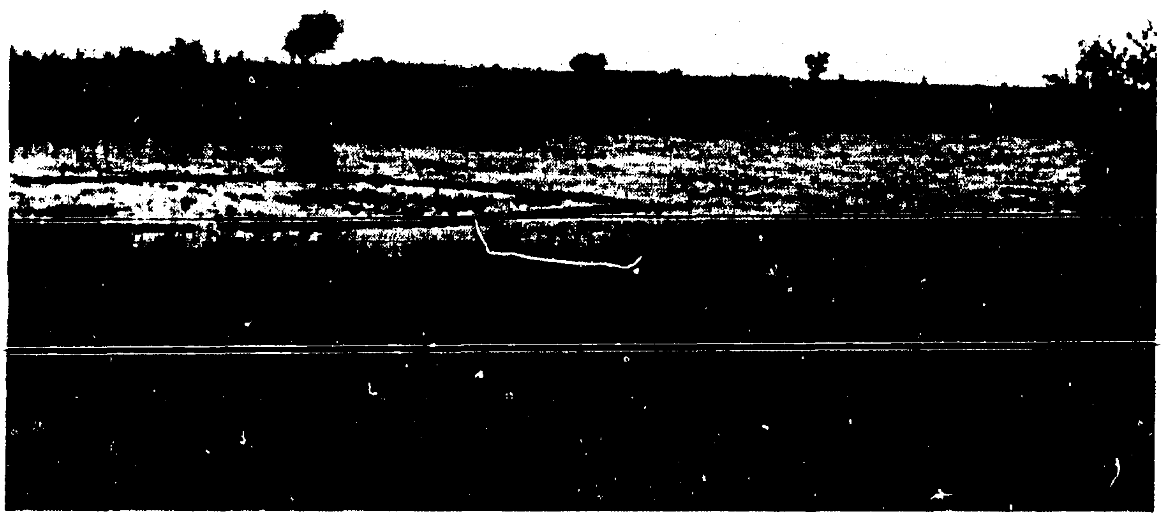
- At the end of the rainy season in 1987, outbreaks occurred of a lethal viral disease known as rift valley fever, around Rosso near Diama Dam and near Foum Gleita Dam. Mosquitos were unusually abundant that year because of heavy rains, ecological changes caused by filling the new reservoirs, and the simultaneous introduction of irrigated rice along the rivers. Local increases in herds of sheep also had a role in the two epidemics.

- The blackflies that transmit river blindness were eliminated from the area around Manantali Dam after the flooding of breeding sites in the Bafing River and the interruption of rapid flow downstream of the dam.

Figure 5: Rice, snails and mosquitos. The change to intensive cultivation of rice *(a)* from the traditional paddy system *(b)* has created favorable habitats for both malaria mosquitos and bilharzia snails.

Figure 5: Riz, mollusques et moustiques. L'adoption d'une riziculture intensive *(a)* à la place du système des casiers traditionels *(b)* a créé des habitats favorables pour les moustiques du paludisme et les mollusques à bilharziose.

(a)



photos: Jobin

(b)

Health Care and Information Flow

- Health care facilities in the basin were inadequate to deal with the severe and expanding health problems found in 1994. Furthermore, the industrial and commercial agricultural developments, especially in the Richard-Toll area, were not providing any support to offset the increasing health problems caused by their projects. Despite the inability of government agencies to deal with the existing problems, the agro-industrial developments rapidly expanded.

- There was limited monitoring of health conditions around OMVS or agro-industrial projects by national health authorities or by the OMVS. Despite the direct effects of OMVS projects on the health, agriculture, livestock, and environmental sectors, little information flowed between them.

- A dangerous gap in communication between health planners and water planners, even at the international level, has led to the neglect of recommendations on improved design and operations of water resource systems in the basin. The disease problems were predictable and planners should have designed the projects to avoid them. The United Nations (UN) and other agencies have been issuing warnings about these problems for the last 30 years. The Panel of Experts on Environmental Management (PEEM), a UN panel, recently offered its support to help the OMVS in its continuing effort to improve development of water resources in the tropics.

Conclusion

This overall assessment showed that during the first decades of the development of the Senegal River Basin by OMVS and national organizations, several health problems have increased to crisis proportions. If the current development policies continue unchanged, the deterioration of health among populations in the river basin will seriously reduce the expected benefits of OMVS programs. Fortunately, the OMVS has the opportunity to coordinate a sustainable attack on these problems, within its original mandate to promote development.

RECOMMENDATIONS

Based on our 1994 field observations on health and ecology in the entire Senegal River Basin, on analyses of many health and engineering documents provided by authorities in the basin, and on close observations of current conditions at the heart of the OMVS—the Dam at Manantali—we concluded that OMVS is at one of the most difficult and critical periods in its history.

The difficulties we saw were caused by two factors. One was the sensitivity of the fragile ecology of the river basin to manipulations of water, a fundamental requirement for human life and health. The second reason was the severe stress on the OMVS due to delays in completion of the energy project at Manantali.

Opportunity for OMVS

Fortunately, we also saw an important opportunity for the OMVS to overcome both impediments, by taking on a new role as manager of the ecology and health of the basin. The scope of our study does not encompass the entire basin ecology, but focuses on one of the most important components, human health. However our recommendations should be integrated into a comprehensive understanding of the river basin ecology. In this context, we recommend that the OMVS adopt maximization of human health and productivity as one of its immediate objects, and that the OMVS take responsibility for guidance and coordination of a basin-wide program for health.

We feel that this is the best way for the OMVS to overcome most of its present difficulties, for two reasons. The first reason is local, relative to life within the river basin. True development of the resources in the basin must give human health and productivity a major role. Healthy families and highly productive agricultural and industrial labor forces will contribute to more stable and satisfied communities and should also increase the rate of food and crop production much faster than currently occurring.

The second reason is on an international level and related to financing the energy project and other important components of OMVS programs. It is painfully clear to international donors that ecological and health conditions in the basin are deteriorating and that national agencies are unable to cope with the mounting problems. Epidemics of fatal diseases are occurring in the agricultural populations yet no control efforts are being organized. Forests and fisheries are being decimated. Thus one can easily understand the reluctance of international agencies to support further water resource developments, given the precarious ecological and health situation.

The best way for the OMVS to overcome this obstacle is to meet it head on. When donors and lenders see that the OMVS is guiding agencies in the member countries toward an integrated program to maximize health and productivity in the basin, OMVS should find it much easier to obtain support for its projects.

It was in this hopeful spirit that we made the following observations and recommendations.

Linkages

The results of the 1994 field surveys by the WASH team, as well as background information and evaluations supplied by the national Working Groups from Mauritania, Mali, and Senegal, provided a good indication of relationships or linkages between health conditions in the Senegal River Basin and various development policies and projects. Volume 2 of the report describes the linkages most easily discerned from this information, and then recommends specific actions for the OMVS and the member countries to improve health within the overall objectives of integrated development of the river basin.

A number of fairly clear linkages were seen between health conditions and development policies and projects. They included effects due to construction of Diama, Manantali, and Foum Gleita Dams and the subsequent storage of water and regulation of the river; the effect of intensified cultivation of sugar cane and rice in the Lower and Middle Valley, and population movements, especially the migration into the Richard-Toll area of the labor force for new industries and agricultural developments. We also observed a serious lack of coordinated efforts against the problems caused by these linkages.

Effects of Dams

Water levels in the Diama and Manantali Reservoirs were maintained at fairly stable elevations, favorable to the aquatic snails that provoked an outbreak of intense bilharzia transmission near Richard-Toll in Senegal. However, in the Foum Gleita Reservoir of Mauritania large fluctuations in the water level produced conditions unsuitable for the snails, and bilharzia disappeared locally. Also in Manantali Reservoir, after several years of stable levels, the water was dropped fairly rapidly in early 1994, stranding most of the snails on the shore line. Thus, there is considerable evidence that fluctuations should be a useful ecological management technique for snail control and should be investigated.

Occasional cuts in discharge from Manantali Dam must have also reduced the breeding of blackflies immediately downstream of the dam, thus reducing the potential for transmission of river blindness by the blackflies. This impact complemented flooding of the rapids upstream of Manantali Dam where blackflies previously were found, due to filling of the river valley as the reservoir formed.

Intensified Irrigation

Water storage in all three reservoirs made it possible to expand and intensify irrigated agriculture throughout the basin. The intensified irrigation of sugar cane at Richard-Toll and around Lake Guiers created favorable habitats for bilharzia snails. The intensified cultivation of rice, including attempts to raise a second crop during the dry season, has created new breeding sites for malaria mosquitos, and in the Middle Valley has probably increased malaria transmission by lengthening the malaria season.

Storage of water in Manantali Reservoir has resulted in dramatic changes in the character of the annual flood that had previously shaped the ecology of the river basin. Attempts at creating an artificial flood have been only partly successful, with much smaller flows and highly variable timing occurring during the seven years since Manantali Dam began to fill. Changes in the artificial flood have resulted in some reductions in malaria, bilharzia, and diarrheal diseases in parts of the Middle Valley. However, these have been offset by reductions in food supply, which have further continued malnutrition, and by reduction of water supply for communities in the floodplain. The food supply, traditionally including products derived from flood-dependent agriculture, from fishing, and from gathering of foods from the floodplain, has been reduced in quantity and variety. This resulted in malnutrition among children just as serious as it had been before the dam construction, and even in new vitamin deficiencies among adults. The expected improvement in nutrition from increased cultivation of rice and other irrigated crops has not been realized. This was a major disappointment for agricultural expectations.

Population Increases

Population movements into the Richard-Toll area and other parts of the valley have magnified the previous deficiencies in water supply, sanitation and health services, to the point where serious overloading of these facilities has already occurred, and the risk of epidemics of water-associated diseases is high and increasing.

An extremely intense foci of intestinal bilharzia transmission has developed around the sugar cane irrigation system at Richard-Toll. It has drawn international attention since its beginning in 1990, and the European Economic Community has recently opened a modern laboratory there to study the unusually severe form this disease has taken (**Figure 6**). A major factor in the intensity of the disease around Richard-Toll is the high population density from the various labor groups which work in the cane fields, in the sugar mill, in the plastics factory, and in other related agri-businesses in the areas. Because no improvements were made in water supply and sanitation, the transmission of bilharzia has spread to the entire population. Poor sanitation in this area, as well as the widespread occurrence of industrial and agricultural chemicals, also poses a risk to water supplies for St. Louis and Dakar, which are being derived from the Senegal River and from Lake Guiers.

Basic needs for water supply, sanitation, and health services are being neglected in the Senegal River Basin, despite plans for major improvements in Dakar and other urban areas in the OMVS member countries. This inequity is magnified by the occurrence of much more widespread and serious diseases associated with water in the basin, and the continuing malnutrition. A parasitic infection in a malnourished child produces much more severe disease than does either problem occurring alone. Thus, the people affected by these multiple problems need these basic amenities more than most people.

It is doubtful that development plans for the basin will be successful if current health problems are not dealt with. If electrification is not used to improve irrigation, village water supplies and health care facilities along the river, but provided instead primarily to urban areas outside the basin, the national plans for improving rice production will be jeopardized, and rural populations from the basin will migrate to Nouakchott and Dakar to avoid malnutrition and diseases.

Despite the serious problems and clear linkages between development projects and disease, little or no coordination and communication was observed between the agencies for agriculture, livestock, health and the OMVS, key actors in the river basin development. Thus outbreaks of disease occurred without warning, and little was done to remedy the situation.

The most important example of the lack of action was the large outbreak of intestinal bilharzia discovered five years ago in Senegal. By 1994 no integrated plan had been proposed for its control. Our study determined that this disease has further spread to Mauritania, and also to ~~several new locations in Senegal including the entire perimeter of~~ Lake Guiers. There is potential for additional spread throughout the basin in conjunction with rice cultivation and other crops which require large amounts of water such as sugar. Yet

Figure 6: Intestinal bilharzia affects agricultural workers. The severe form of intestinal bilharzia often leads to early death in irrigation workers.

Figure 6: La bilharziose intestinale affecte les ouvriers agricoles. La forme grave de la bilharziose intestinale entraîne souvent le décès précoce des ouvriers de l'irrigation.

photo: Henrioud of WHO

there are no plans to modify agricultural plans to reduce the risk of this disease. This situation provides an excellent opportunity for the agricultural agencies to reduce disease in the agricultural populations and thus further increase productivity. These opportunities were not being exploited in the Senegal River Basin, despite decades of recommendations from international health and agricultural agencies.

The lack of coordination of health measures with development projects was observed at all levels in the Senegal River Basin, including international health agencies and river basin planners. If this situation persists there will be increasingly serious health problems throughout the basin, with potentially severe consequences even for urban areas in Senegal and Mauritania.

Recommended Activities

Our 1994 study identified several important and sustainable measures that the OMVS could take to improve health in the basin. These included coordination of activities by national Ministries of Health, as well as changes in water levels at Manantali and Diama Dams and other operational techniques. These operational measures will be much more cost-effective than unilateral actions by national Ministries of Health. Because of its unique and central position in the Senegal River Basin, we have recommended a new organizational emphasis for the OMVS, as well as the specific conventional health measures to be taken against the major water-associated diseases. These recommended activities conform to the original objectives of the OMVS for integrated development.

Organization

The present organization and coordination of health services with development policies and projects in the basin is not adequate and serious problems are evident. Thus we recommend the following seven organizational measures:

- That the OMVS takes the lead role in coordinating and guiding integrated development of health and water resources in the basin. Improved health of the population in the river basin will improve agricultural and industrial productivity. With improved productivity, new jobs will be created in the basin. Furthermore, if the basic social infrastructure of water supply, sanitation and health services is also improved, it may be possible to reverse the current migration out of the basin, and even attract urban dwellers to return. This would further the overall objectives of development that led the member countries to create the OMVS in 1972.

- To coordinate the integrated development of health and water resources, the OMVS should establish an Integrated Health Coordination Unit, headed by a senior public health physician. This OMVS Health Unit should be located in the river basin near Rosso or St. Louis, and should also include personnel from the agriculture and environment sectors.

- The three member states should appoint senior health officials to advise their OMVS national representatives on cooperation with the OMVS Health Unit. These officials should come from the National Scientific Working Groups that assisted WASH in preparing this report, and should define their own National Health Action Plans as an initial activity.

- The first activity of the OMVS Health Unit should be to organize a senior management seminar on water-associated diseases and development. The World Health Organization could assist in the seminar as they have recently organized similar seminars through a UN Panel called PEEM, both at Akosombo Dam on Lake Volta, and in Zimbabwe. PEEM is based at the World Health Organization offices in Geneva, Switzerland and has offered its assistance to OMVS.

- The second activity of the Health Unit should be to develop an Annual Integrated Health Program, starting with recommendations from this report. The Annual Program should be developed by March or April each year in order to guide the Consultative Committee on Common Works of the OMVS which is held each May.

- An effective communication system needs to be established in the river valley to provide two-way communication between the OMVS and health agents in riverside communities. A practical system that would overcome present problems with overland travel in the rainy season could be based on river boats that would regularly call at the regional capitals along the river would and maintain communication links with the OMVS Health Unit and with OMVS in Dakar. These boats could also include diagnostic laboratories and could be linked with local transport for reaching remote communities.

- The Ministries of Health in each member state should establish Operational Field Units in each region or district, to execute the Annual Integrated Health Program in cooperation with local communities. Their activities could be coordinated by the OMVS communication system recommended in item 6 above.

Operational Field Studies in Reservoirs

During our field study, we observed that operations during early 1994 in Manantali Reservoir had recently caused large reductions in numbers of bilharzia snails in the reservoir, and reductions in the habitats for the blackflies that transmit river blindness. We concluded that sudden changes in water level in the reservoir and river could be integrated into regular operations of Manantali Dam and perhaps Diama Dam, without interfering with normal operations for power generation or ~~agriculture (Figure 7). PEEM has offered to assist OMVS with field studies to develop locally~~ effective methods of this nature.

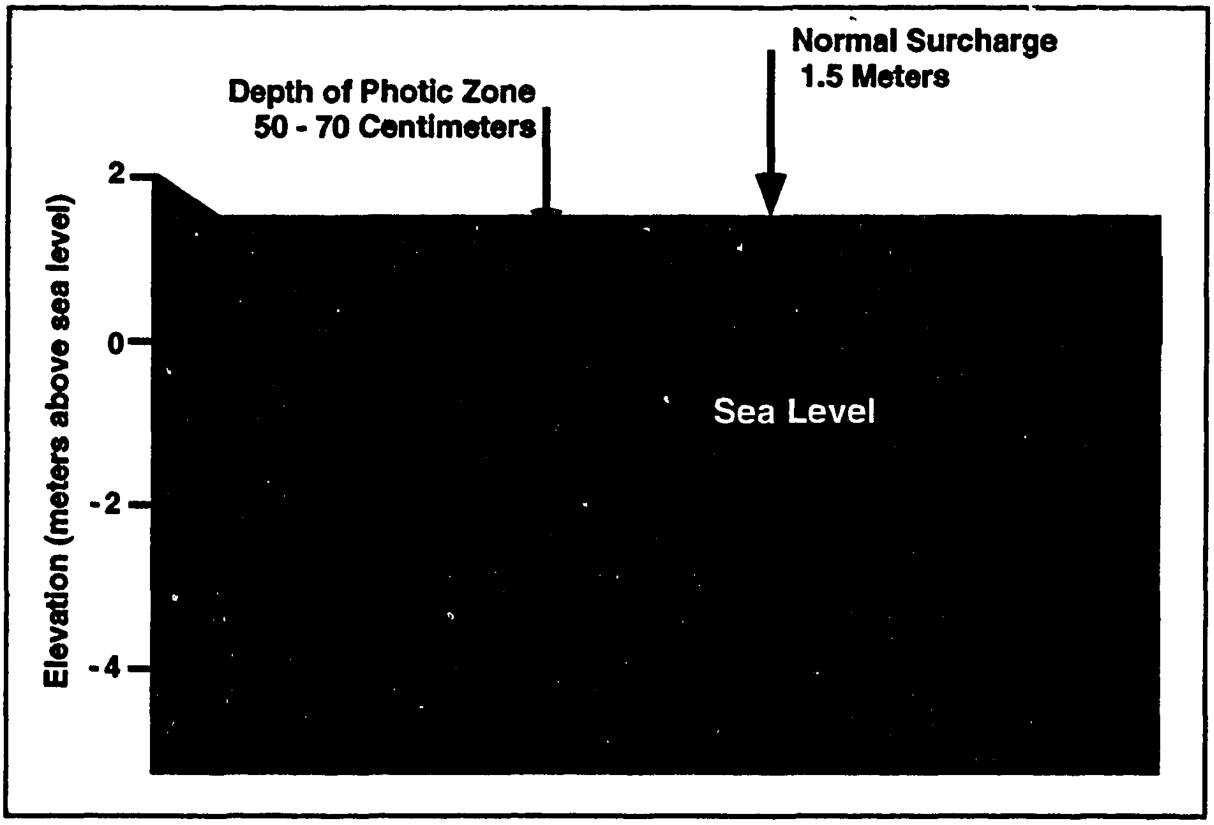


Figure 7: Illustrative Cross Section of Diama Lake Indicating Potential Fluctuation Ranges

We also concluded that these operational measures could be combined with traditional public health measures such as drug distribution, health education, provision of water supplies, and environmental control of breeding sites, as an integrated attack on the disease problems. This combination of operational and public health measures would form a key component of the Annual Integrated Health Program recommended in the previous section of Organization.

In the Middle Valley, there was a link between agricultural practices such as intensified rice cultivation, and longer malaria transmission seasons. Therefore, national policies on the promotion of rice cultivation should be reviewed with the intent of finding modifications of the current practices, which will reduce production of malaria mosquitos. Recently, PEEM has also initiated studies to evaluate such modifications in cooperation with the National School of Medicine in Mali. The results may be applicable to the Senegal River Basin.

We thus recommend that OMVS request assistance from PEEM to assist in the design and management of operational field studies in the various reservoirs and irrigation systems, during the transitional period before energy production begins at Manantali Dam.

Bilharzia (Schistosomiasis)

There is considerable evidence available from published reports, from studies presently underway in the Delta, and from limited probes undertaken by the WASH team, that regulation of the river and expansion of irrigation has spread bilharzia throughout the river basin. This pattern of expanding disease due to water resource development has also been observed in many other parts of the world. Several factors contributed to the increase of bilharzia to epidemic proportions. The factors that increased breeding and survival of the bilharzia snails were the reduction in salinity of the lower reaches of the river, maintenance of a stable water level in Diama Reservoir, and increased shoreline vegetation. Other factors included immigration of people from areas where the bilharzia was already established, and the contamination of waterbodies in the Senegal River Basin with excreta from infected persons, containing eggs of the bilharzia parasite.

Because of the serious nature of this bilharzia outbreak, and its continuing spread in the Lower Valley, a coordinated emergency program to control it should receive the highest priority by the OMVS and the member states.

Nutrition

The present strategies of the OMVS and member states to expand irrigated agriculture, particularly for rice production, have not led to the anticipated improvements in food availability and nutritional status for residents near the river. Improvements in the food and nutrition situation ~~along the river would require the re-introduction of an annual artificial flood of sufficient volume~~ and length to allow farmers to grow flood-recession crops, and also revision of national policies in Mauritania and Senegal in order to promote crop diversification in irrigated areas.

It is important that a system be put in place to ensure periodic monitoring of the nutritional situation in the valley. Such a system could include data collection on two facets of the food and nutrition situation at five-year intervals. The first facet is food availability at household level. The second is the nutritional status of household members.

Diarrheal Diseases

The OMVS should play a lead role in reducing widespread diarrheal diseases by conducting a detailed study on the needs for water supply and sanitation facilities in all communities in the basin, and by cataloging the needed projects in order to request construction funds from national and international agencies.

Malaria

Given the importance of malaria as a major public health problem in the basin, more resources should be found to provide people with timely and correct treatment through improved health services. Accurate microscopy should be expanded, to improve diagnoses and treatment, and also to improve epidemiological information. Microscopists should be provided with refresher training and with supervised quality control. A system should also be established to coordinate malaria research in the area, especially with regard to the impact of rice cultivation and other agricultural practices, and on the effectiveness of using bed-nets for malaria control.

Sanitation

It is recommended that a system be established to monitor bacterial and chemical water quality in the river, irrigation canals, and drains. A monitoring system, along with establishment of water quality standards, is needed to ensure that contaminants do not exceed the levels recommended to safeguard the lives of the human and animal populations in the Senegal River Valley.

Rift Valley Fever

An epidemiological study should be carried out to determine the factors that caused the Rift Valley Fever epidemic in Mauritania in 1987. The findings should be used to design an early warning system for the prevention of future epidemics, in cooperation with international authorities on this and other lethal viral diseases transmitted by mosquitos. An essential component of such a system has been initiated by the Pasteur Institute in Dakar; the monitoring of viral transmission in animals. This should be expanded in cooperation with veterinary and health authorities. Epidemics affecting people are normally preceded by increased transmission and abortions in animals.

VOLUME 1

FINDINGS

Chapter 1: Introduction

This report describes the results of the Health Master Plan Study conducted for the Senegal River Basin Authority in 1994 by the WASH Project, with the support of the U.S. Government. This international authority for developing the water resources of the Senegal River is known by its French initials as the OMVS.

About two million people live in the Senegal River Basin. They are closely dependent on the river for their livelihood and had suffered decades of drought and famine because of the fluctuating rainfall of the Sahel Zone in which the river is found (**Figure 8**). Most people raise their own food; thus the droughts of the 1970s and 1980s caused severe malnutrition, caused large migrations out of the valley, and hampered the general development of communities in the basin.

With the large flow of the river and the steep gradient in the Upper Valley, plans had been under discussion for years to build hydroelectric power dams in several locations in Western Mali and Northeastern Guinea. A UN-sponsored study in 1970 identified sites for several dams.

In 1972, partly in response to the severe drought and famine of the early 1970s, the Senegal River Basin Authority, OMVS, was created by the governments of Mali, Mauritania, and Senegal to develop water resources of the Senegal River. The objectives of the OMVS included improving income and economic growth in the three countries, as well as moderating the effects of drastic climatic changes on people and agriculture in the basin. The integrated development plan of the OMVS called for construction of or support for:

- Manantali and Diama dams
- River navigation
- Irrigated agriculture
- Urban water supply
- Industrial development

Although the plan envisioned integrated development, there were certain inherent conflicts related to the use of water for generating electricity for industries and large cities at the expense of agricultural use within the river basin. The capitals of Mali, Mauritania, and Senegal, where most of the electricity would be consumed, are located well outside the river basin. Balancing the needs and resources of communities inside and outside the basin has been a major challenge to planners in the OMVS.

ECOLOGICAL AND HEALTH ASSESSMENTS

From the beginning, it was recognized that modification of the river regime would cause ecological changes throughout the basin, including effects on human health. OMVS and the United States Agency for International Development (USAID) conducted a comprehensive environmental impact assessment in 1978 to assess the magnitude of these effects. The 1978 assessment concluded that the OMVS program would not create serious problems.

Figure 8: Contrasts in rainfall cause marked variation in vegetation and agriculture. *(a)* The drought years before 1974 turned the right bank near Foum Gleita to near desert conditions. *(b)* Wet years in 1987 and 1988 turned the left bank near Bakel into a paradise for grazing animals.

Figure 8: Les contrastes de pluviosité à l'origine de nettes variations de la végétation et de l'agriculture. Les années de sécheresse avant 1974 ont fait de la rive droite près de Foum Gleita un quasi-désert *(a)*. Les années bien arrosées de 1987 et 1988 on fait de la rive gauche près de Bakel un paridis du pacage *(b)*.

(a)

photos: Jobin

(b)

USAID assisted OMVS in conducting additional health impact assessments after the 1978 study. These assessments related to viral diseases transmitted by mosquitos and ticks, and other concerns. The predictions generated from these latter studies disagreed with the 1978 assessment, and serious problems with rift valley fever and bilharzia were predicted in two reports: one completed in 1980 and the other in 1984. Differences in the predictions by the health impact studies were partly due to differing understanding of the complexity of the disease transmission cycles, but they were also testimony to a major basis of this report: the fundamental complexity of large ecosystems.

A small health impact assessment on an irrigation project in Mauritania had been completed before the 1978 study by USAID. In 1974, during the design of the Foum Gleita Irrigation System on the Gorgol River, the Mauritanian Ministry of Planning contracted a health impact assessment of the proposed system as part of World Bank pre-investment studies. This health study predicted that malaria and bilharzia would become serious problems in the new system, and several design modifications were suggested to reduce the disease risk. The original proposal for the Gorgol Project was a complex design involving two dams, the triple-cropping of rice, and a large system of canals and dikes.

COMPLETION OF DAMS

By 1986, Diama Dam and Manantali Dam were being constructed and were storing water on the main stem of the river. At the time of this 1994 study, Diama Dam was complete and new irrigation systems around Diama Reservoir were in operation. Water was being released from Manantali Dam to guarantee the irrigation supply in Diama Reservoir. Nonetheless, the hydroelectric turbines, generators, and transmission lines had not been installed at Manantali Dam because of delays in financing. Provisions for the development of navigation were also delayed.

However, on the Gorgol River in Mauritania, Foum Gleita Dam and a small irrigation system had been constructed by this time. The original design had been drastically revised, partly to simplify water management and agricultural practices and to avoid the predicted health problems (**Figure 9**).

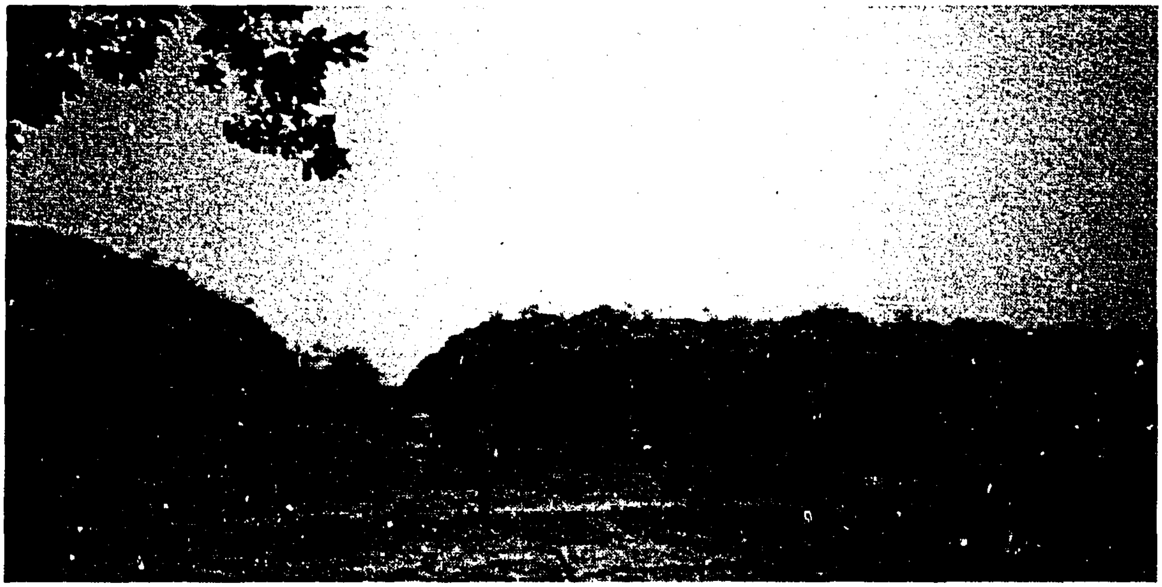
HEALTH CRISES

Soon after construction of the dams at Diama, Manantali, and Foum Gleita, severe health crises occurred very close to each of the them. All three dams started filling about 1986, and in the rainy season of 1987 severe epidemics of rift valley fever occurred near each of these new reservoirs. About 200 people died in Mauritania and perhaps an equal number near Manantali Dam in Mali. In Mali, the official report suggested that the epidemic was yellow fever, but details were strikingly similar to the rift valley fever episodes near Rosso and Kaedi.

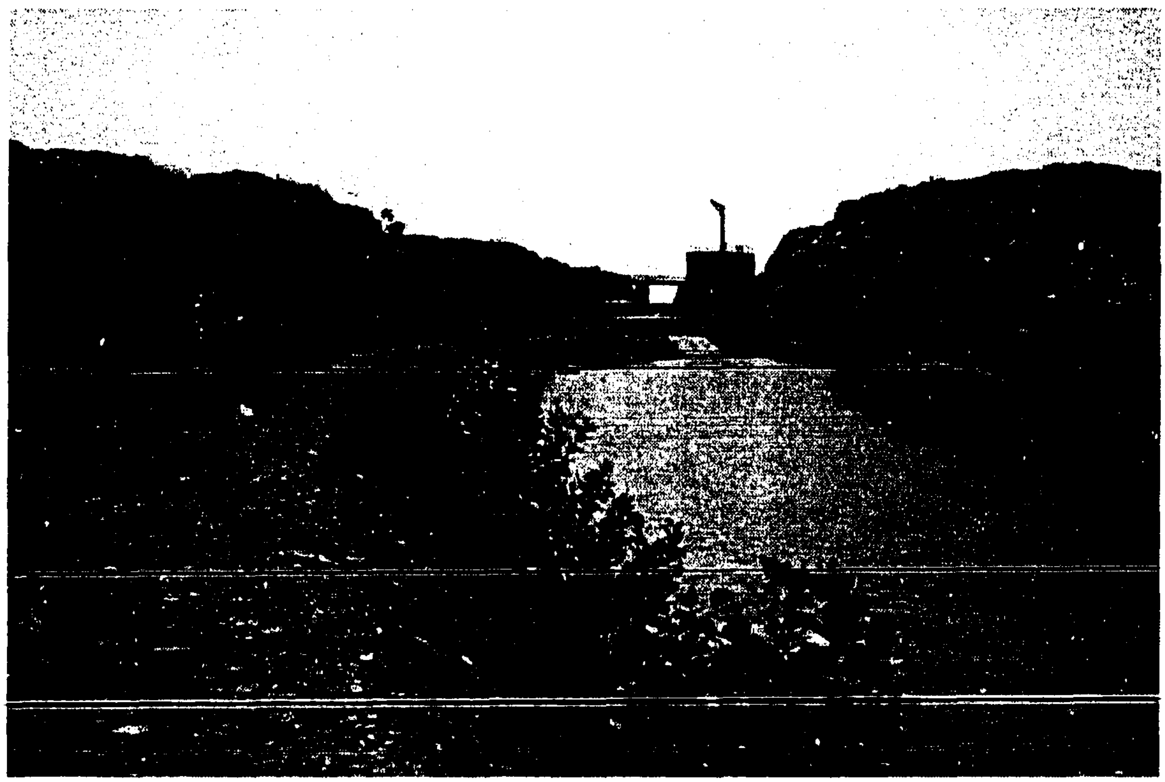
This was the first record of rift valley fever in West Africa. It had been observed only once before as a human disease in epidemic form at Aswan Dam on the Nile River in 1977. Similar to the situation in the Senegal River reservoirs, the epidemic at Aswan occurred the

Figure 9: Foum Gleita irrigation scheme on the Gorgol River in Mauritania. In 1974 the WaWa Ridge was a rocky barrier across the dry bed of the Black Gorgol River *(a)*. But 20 years later it was closed by a concrete dam and stored irrigation water to supply over 1,000 hectares of rice near Foum Gleita *(b)*.

Figure 9: Périmètre d'irrigation de Foum Gleita sur le fleuve Gorgol en Mauritanie. En 1974, le pont WaWa était une barrière de pierre sur le lit à sec du flueve Noir Gorgol *(a)* mais 20 ans après, un barrage en ciment le fermait et ainsi, il devenait un réservoir d'eau pour irreguer plus de 1000 hectares de riz près de Foum Gleita *(b)*.



(a)



photos: Jobin

(b)

year that Lake Aswan filled to its Full Supply Level for the first time. The risks of this disease had been identified in the 1980 and 1984 health impact assessments.

Closely following the rift valley fever outbreaks, a new and very serious focus of intestinal bilharzia appeared in the sugar cane irrigation system at Richard-Toll. The outbreak was clearly related to the expanded and intensified cultivation of sugar cane made possible by the constant supply of fresh water from Manantali and Diama reservoirs, and from the large increase in population that followed development of related agricultural and industrial projects. This was the first outbreak of the severe form of intestinal bilharzia in the Senegal River Delta. Increased bilharzia transmission had not been predicted in the 1978 health study, but had been predicted in the other studies.

The rift valley fever and bilharzia epidemics were receiving international attention by 1990, and have become the subject of intensive research in the basin. International research agencies have built a new laboratory at Richard-Toll because of their interest in the intense nature of bilharzia transmission in that area. The Pasteur Institute of Dakar has regularly assessed rift valley fever in animals throughout Senegal.

Because of the risk that these diseases would increase, the OMVS and USAID agreed that it was important to develop a Health Master Plan for the future of the Senegal River Basin. An initial attempt to develop the plan was aborted in 1991 because of contractual problems with the consulting firm responsible for the study.

PURPOSE OF THIS STUDY

USAID subsequently contacted its global program, WASH, to conduct a short assessment and to develop recommendations for the Master Plan for Health. The task given to WASH in this 1994 study was to identify existing data and to collect new data to evaluate current health conditions related to bilharzia, malaria, diarrheal diseases, nutritional status, guinea worm disease, river blindness, and rift valley fever. The evaluations of these health conditions are found in Volume 1 of this report, with detailed information in the annexes. As part of its field study, WASH agreed to evaluate the links between water management practices and health conditions. WASH also agreed to prepare recommendations for an Action Plan for OMVS and its member states. The plan intended to reduce the negative health effects of their development projects. These latter two items are presented in Volume 2 of this report.

The WASH study reported in this document was thus a continuation of the integrated approach to the assessment of the ecological and health impacts of river development by OMVS and its member states. The WASH study included the formation of multi-disciplinary Working Groups from Mali, Mauritania, and Senegal, as well as assistance from local and international scientists and engineers. ~~The disciplines included anthropology, rural development and information systems, environmental~~ planning and hydraulic engineering, medicine and veterinary medicine, and technicians with backgrounds in ecology and parasitology.

Because of the early activities related to environmental assessment carried out by OMVS, the background material available on the Senegal River Basin was extensive. It provided a historical overview of changes over a period of 20 years. It is unusual to find documentation this complete for African river basins; therefore, the first part of the WASH study was directed at analyzing this material.

A preliminary mission by WASH in January 1994 established an office in the OMVS headquarters in Dakar, initiated the field work, began a review of existing data, and organized Working Groups of local experts in each of the three member states. The WASH field team was assembled in March for a planning meeting and arrived in Senegal in the first week of May. With a deadline for the draft report of mid-August, this allowed three months for the field work and report writing.

After introductory meetings with the Working Groups in Dakar, Nouakchott, and Bamako, in mid-May of 1994, the WASH field team carried out field work in the Delta and up the right bank towards Kayes in Mali. The WASH team collected additional information along the left bank in Senegal during a second expedition in June. The team then went to Manantali Dam in July for a short and final expedition. Several additional meetings were held with the Working Groups in the national capitals as the field work progressed. This geographical coverage involved extensive travel on commercial airlines, in four vehicles, boats, and light aircraft.

CONCEPTUAL APPROACH AND METHODOLOGY

The general approach of the WASH study was a combination of data collection and observations in the field, interviews with knowledgeable persons, village organizations and family groups along the river, and exploration of major themes and proposals with OMVS and Ministry of Health staff in the three countries. Review of existing documentation also constituted a major part of the team effort, especially for the disease problems around Richard-Toll in Senegal, and for the resettled villages near Manantali Dam, which have been studied extensively by national and international groups.

Several meetings were held with the OMVS engineering staff at Diama Dam, at Manantali Dam, and at the OMVS Operations Coordination Center at Rosso, Mauritania. A thorough review was made of the design, operating background, histories, and future plans for each of the dams, as well as the information system employed by the OMVS for river management. The purpose of this exploration of the river management system was to assist the OMVS in developing environmental management techniques for the control of disease vectors, which do not conflict with the primary functions of the dams. Similar explorations of the health information and management systems were conducted to find ways to integrate these two systems with other geographical information systems being developed in the basin.

~~The WASH study of 1994 also included a collection of original epidemiological and biological data~~ at selected points along both sides of the river, from the ocean at St. Louis upstream to Manantali Dam. At several strategic points, temporary parasitology laboratories were established and nearby human communities were examined clinically for bilharzia and malaria. In the same communities, household interviews on health and socio-economic conditions were conducted. Rapid biological surveys were conducted for snails and insects near these same sites, in combination with analysis of hydrologic and environmental data from OMVS and other agencies.

The field expeditions were reconnaissance surveys meant to supplement or probe the large number of existing reports prepared by other groups. The two weeks available for visits in each country were used to conduct limited probing at critical points in the large geographical area covered by the river basin. This required extensive and rapid travel, but did not allow for the sampling of large and randomly selected populations. The probing approach used in the 1994 WASH field study was designed to make the best use of the limited time allowed by the contract.

The WASH field team comprised 16 international and local members, as well as a small staff at the WASH office in Dakar. Drivers, pilots, and boat captains were employed as travel needs required. During the field work, the team generally travelled together and met daily to discuss findings and analyses.

The National Working Groups met with the WASH field team before the field operations began, provided some guidance to the field team in setting priorities for the short field studies, and provided the most recent information available at the national level. They also conducted some supplemental data collection themselves. Given the short time available to complete the field work, and the vast distances between the National Working Groups in Dakar, Nouakchott, and Bamako, we sincerely regretted that we were not able to more fully use the enormous potential of the National Working Groups. Individual scientists were also consulted extensively in the field, especially those attending the inauguration of the new bilharzia research laboratory in Richard-Toll. Members of the WASH field team and National Working Groups are listed in an annex.

In late September 1994, the three National Working Groups and representatives from OMVS were convened in a Final Review Meeting by WASH at St. Louis, Senegal, to review the draft of this report. On the basis of three days of discussion, the Final Review Meeting approved this report, after suggesting modifications. The draft report and comments from the Final Review Meeting were discussed with the Secretary General of OMVS, formally approved by the USAID Mission in Dakar, edited by a WASH editorial team, and then published in English and French in Washington, D.C. in late December 1994.

HEALTH IMPACTS OF LARGE DAMS IN AFRICA

The economic benefits of building large and small dams are numerous. But too often, in the name of "development," the social and health costs that accrue from these impoundments and the irrigation schemes they generate are underestimated. Examples in Africa show that they can become a burden for national governments and a curse for millions of affected people. Close parallels to what is happening in the Senegal River Basin occurred in the wake of earlier dam projects in Africa: the Aswan dams in Egypt, the Sennar and Rosaires dams in Sudan, and the Akosombo and Kpong dams in Ghana.

Although the first Aswan Dam was built in 1902, it was so small that it did not affect irrigation practices in the country. The traditional form of agriculture in most of Egypt remained basin irrigation, which depended on the annual flood of the Nile. This was adequate when the human population was low, but increasing population pressure in the Nile Valley necessitated the heightening of the dam in 1933, and the construction of the final super dam in the 1960s.

The first enlargement of the dam permitted the transformation from basin to perennial irrigation throughout the Nile Valley. Weeds and snails infested the earthen canals. Within three years, the overall prevalence of bilharzia in Qena and Aswan governorates increased from under 10 percent to nearly 50 percent. The recent High Dam at Aswan permitted a further expansion of irrigation into the desert, but the health costs were high. Urinary bilharzia continued to expand in the Upper and Middle Valleys. By the 1980s, intestinal bilharzia replaced urinary bilharzia in the Delta as the major form of the disease, where it infected more than four million people. Worse, it had begun an inexorable spread upstream into the Fayoum Basin and along the Nile River as far as Aswan.

Intestinal and urinary bilharzia increased mainly as the result of too much open-ditch irrigation. The continued flooding of the fields led to a buildup of salt and a reduction in soil fertility. The salt problem was dealt with by the excavation of more and more drainage ditches, and the remedy for the infertile soil was to use large amounts of artificial fertilizers. This turned into a vicious circle: a massive capital expenditure for the government and farmers, water pollution, weed-choked canals and drains, more snail infestation, and more bilharzia.

The lack of adequate drainage was most acute in the Nile Delta and increased the threat of mosquitos. Valuable land in the lower Delta was also being lost to coastal erosion and salt water intrusion. To deal with the agricultural and health problems, the government of Egypt was forced to borrow hundreds of millions of dollars from the World Bank and other foreign donors. Between 1980 and 1984, the cost of drugs and molluscicides alone for bilharzia intervention each year amounted to more than $5 million.

Bilharzia was less of a threat around Lake Nasser because of low population density. But the high-water level of the lake in 1977 may have been a key factor in the devastating outbreak of rift valley fever that caused 18,000 cases of disease and about 600 deaths. The same disease struck Rosso, Mauritania, in 1987 after Lake Diama rose to new, high levels. That epidemic killed almost 300 people. The Sennar Dam across the Blue Nile in Sudan was completed in 1924. By 1938, the impoundment it formed fed major and minor canals that extended for 4,000 kilometers through the Gezira irrigation scheme. Before the project, bilharzia had not been detected in the area, but between 1940 and 1945, 45 percent of the children had contracted *Schistosoma haematobium*. Intestinal bilharzia soon invaded the Gezira and Managil schemes, rising from about 5 percent among children in 1947 to about 80 percent in 1973. The construction of the Rosaires Dam in 1966 eliminated long dry periods in the new canals and helped to promote the upsurge in transmission. The intensity of *Schistosoma mansoni* infection in some sections of Gezira (as measured by egg counts) soon reached extremely high levels. The wetter conditions also encouraged malaria and other mosquito-borne diseases.

The Volta Lake in Ghana, the world's largest man-made lake, is in many ecological respects a macrocosm of Lake Diama and Lake Manantali. It started to fill in 1964 upon completion of the dam at the Akosombo gorge. The scheme was part of the Volta River Project, the principal goal of which was to stimulate diversification of the Ghanaian economy by providing cheap hydroelectric energy for aluminum production and other industries, export, and domestic electrification, thereby lessening Ghana's dependence on primary commodities, especially cocoa. After final and controlled filling in 1967, the dam has lived up to its potential for electrical generation. But one trade-off of this was the most rapid epidemic of urinary bilharzia ever reported. From extrapolation of health records, the number of people with the disease in the lake basin most likely increased from under 10,000 just before lake formation to more than 120,000 in 1971. Falciparum malaria increased as well in newly formed towns and villages. The only tangible health benefit was the reduction in transmission of onchocerciasis, because of the inundation of *Simulium* breeding sites. As the productivity of the lake decreased over the years, the prevalence and intensity of bilharzia dropped slightly, but the main effect of this was the decimation of fish stocks and the fishing industry.

A smaller dam, at Kpong, just below Akosombo, came into operation in the early 1980s. Its purpose was to increase hydroelectric generation for export and national use and to expand irrigation in the nearby arid plains. The irrigation network has remained small and the threat of significant bilharzia transmission in the canals never materialized. However, the controlled water that flowed into the lower Volta River, which led to increased weed growth, created a favorable ecological niche for *Biomphalaria pfeifferi*. This resulted in a high prevalence of intestinal bilharzia in villages around the coastal center of Ada. As in Egypt, the cessation of river flooding in the Volta Delta exacerbated coastal erosion. The old beach-front section of Keta was completely destroyed.

Bilharzia, malaria, and other diseases became endemic in previously non-endemic areas following water development projects. Yet, in the past 40 years, construction of small, medium, and large dams has accelerated in Africa. In the Nyanzo province of Kenya, about 50,000 small impoundments were created between 1957 and 1960. The lessons learned from the larger projects are that health and social issues should never be underestimated in the cost and benefit equation. In the long run, preventive measures that can be institutionalized ahead of time are always cheaper than reactionary steps.

Chapter 2: History of Natural Conditions and Water Resource Development

GEOGRAPHICAL SETTINGS

Major Landscapes

The Senegal River Basin covers 290,000 square kilometers in four countries: Guinea, Mali, Mauritania, and Senegal. The basin can be divided into three natural regions on the basis of topography and bioclimatic conditions: the Upper Basin above Bakel (218,000 square kilometers), the Middle Valley between Bakel and Dagana, and the Delta region from Dagana to the Atlantic Ocean (72,000 square kilometers) for a total of 290,000 square kilometers.

The Upper Valley receives from 700 to 2,000 millimeters of rainfall annually and provides most of the water flow in the river. Land elevations vary from 1,540 meters in Mount Fouta Djallon in Guinea to 200 meters for highlands surrounding Kayes in the Baoule and Kolimbine rivers. Soils are very sensitive to erosion, especially where the Soudanian vegetation of woody savannah has been destroyed. Other highlands such as the Affole in Mauritania, Tambaoura and Manding Plateaus in Mali, and Oua Mountains in the Gorgol River Basin are about 400 meters high. The main river channel is very narrow and deep with steep sloped banks, which limits the soil resources available for irrigation.

The floodplain starts from Bakel and runs through desertified sahelian zones. The longitudinal slope at the river drops and the channel presents a well-developed meander system with many distributaries and topographic depressions. The natural vegetation is typically that of wetlands with acacia located in seasonally flooded areas. The margin of the floodplain is dominated by sahelian species, which develop under annual rainfall amounts between 150 and 250 millimeters.

The bottom of the main channel is very unstable with many sand bars. Under natural conditions, the river floods annually inundate a floodplain that is 25 kilometers wide at some locations.

The mouth of the river is an estuarine environment during the dry season from St. Louis to 250 kilometers upstream. Before the construction of Diama Dam, there was salt water intrusion. The Diama Dam was constructed to isolate the Delta and Lower Valley from salt water intrusion and allow the irrigation of fertile deltaic and alluvial soils.

Hydrological Network

The Senegal River, with its 1,790 kilometer length, is the second major river after the Niger (4,200 kilometers) in West Africa. The major tributaries, the Bafing (750 kilometers), Bakoye (562 kilometers), and Faleme (625 kilometers) originate from the Guinean part of the basin in the Fouta Djalon Mountains. The other tributaries situated further downstream, such as the Kolimbine (450 kilometers) and Karakoro (310 kilometers), are of minor importance.

Downstream from Bakel, water flow decreases drastically and only temporary systems such as the Oued Savalel, Gorfa, and Gorgol rivers contribute negligible amounts of water to the Senegal River. They tend to function as distributaries during high flows or stages in the main channel. The process is very pronounced for deltaic systems of Doue, Koundi, Djeuss, Gorom-Lampsar, and Taouey.

Because major diseases in the Senegal River Basin are water-related and these diseases have been drastically affected by recent changes in water management, the distribution of the diseases should be studied in terms of their place in the hydrologic network, by sub-watershed, or lake units.

WATER RESOURCES BY SUB-BASINS

In this report, the health and environmental findings are organized by sub-basins of the Senegal River Basin. Some sub-basins are further divided into national components, especially the right bank of the river in Mauritania and the left bank in Senegal. For report purposes, the figures for the entire sub-basin were summarized, aggregating data from both sides of the river.

Guinea

Most of the flow in the Senegal River is derived from rainfall on the mountain forests of Guinea. There is high rainfall in most of the catchment area within Guinea. Thus, although Guinea is not a member of the OMVS, it supplies a large part of the water managed by OMVS.

Upper Senegal River

The upper part of the basin under regulation by OMVS is primarily in Mali, including tributaries flowing into Lake Manantali.

Lake Manantali

Lake Manantali in Western Mali was formed by the Manantali Hydroelectric Power Dam (**Figure 10**). The lake began to fill in July 1987 and first reached spillway level of 208 meters above sea level in August 1991. Lake Manantali has a maximum storage volume of 8 cubic kilometers of water. The mean flow in the river at Manantali, which is on the Bafing River tributary, is 12 cubic kilometers per year, indicating a mean detention time in Lake Manantali of eight months.

If the flow out of Manantali Dam is regulated at 200 cubic meters per second or 6.3 cubic kilometers per year, the reservoir could supply up to two years of flow in a drought. If the mean discharge is regulated at the proposed 300 cubic kilometers per year, there would be enough storage for only 15 months in a drought. Thus, projections for energy generation indicate that the dam would be forced to reduce generation one year out of four because of

Figure 10: Manantali Dam astride the Bafing River in western Mali, 1992.

Figure 10: Barrage de Manantali sur le Fleuve Bafing à l'ouest du Mali, 1992.

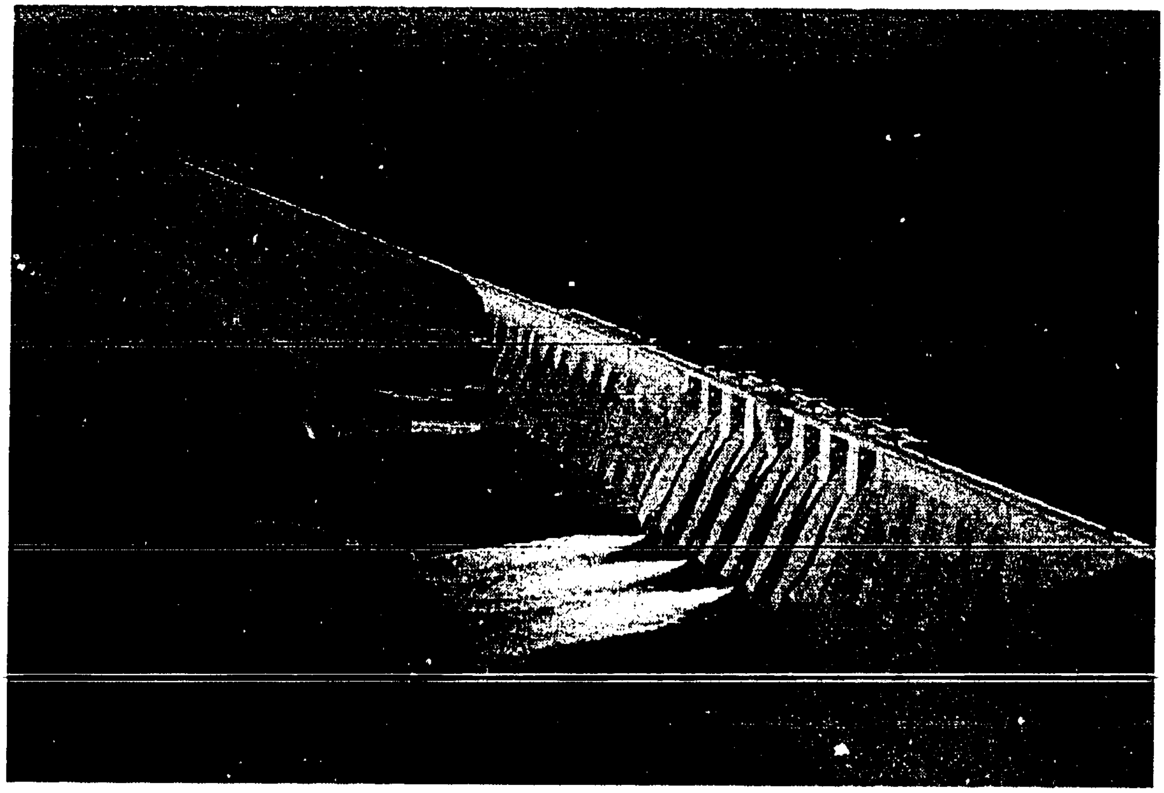


photo: Gregory Leeds

insufficient flow into the reservoir. Agricultural and urban water supplies downstream would also be affected one year out of four.

Bafing River

The Bafing River comes from the Fouta Djallon of Central Guinea and supplies the flow into Manantali Reservoir.

Bakoye River

The Bakoye River in Western Mali meets the Bafing River downstream of Manantali Dam at Bafoulabe. This junction is the beginning of the main stem of the Senegal River.

Middle Senegal River

The banks of the Middle Valley have been the location of traditional recession agriculture for centuries in the Senegal River Basin. The Middle Valley has two tributaries: the Faleme River, which originates in the mountains of Guinea, and the Gorgol River, which originates in the high plateau of southeastern Mauritania.

Faleme River

The Faleme River begins at the border between Mali, Senegal, and Guinea, following the Senegal border north to its junction with the Senegal River upstream of Bakel.

Gorgol River

A dam was constructed at Foum Gleita on the Black Gorgol River in 1986 and supplies water for eventually irrigating about 10,000 hectares of rice fields about 100 kilometers upstream of the Gorgol River confluence with the Senegal River at Kaedi. The reservoir fills to a Full Service Level of about 50 meters above sea level, nearly touching the town of Mbout. About 27,000 people should eventually settle in the new irrigation scheme. Only one rice crop a year is grown in Foum Gleita. General agricultural practices follow traditional cropping patterns, and intensive cultivation is not practiced in the Willaya Gorgol Irrigation System.

Delta

The Delta area was traditionally defined as the lower river reach from the ocean up to Dagana where the salt wedge intruded each year when the river flow stopped. Since then the creation of Lake Diama has changed the hydrology, and the "Delta" now refers to the area downstream of Diama Dam.

In addition to the creation of a large freshwater lake, Diama Dam and related water projects have drastically changed the seasonal pattern and character of flows below the dam to the Atlantic Ocean, and also have modified the plume of fresh water and sediment that previously reached out many kilometers into the ocean. Besides easily perceived changes in coastal ecology, the influence of the regulation at the river on marine fishing, and thus on the nutrition of people in the river basin, is important.

Lake Diama

Lake Diama was formed after August 1986 when Diama Dam was completed. The spillway level of Diama Dam is adjustable and the primary purpose of the data is to provide a continuous supply of fresh water for human uses in the Delta, and to allow large boats to navigate from the ocean to Mali by passing through a lock (**Figure 11**).

At the current operating level of 1.5 meters above sea level, the storage volume in Lake Diama is 0.25 cubic kilometers and the backwater influence of the lake extends upstream 360 kilometers to the Guede-Boghe area. At a lake level of 2.5 meters above sea level, the highest projected operating level, the storage volume goes up to 0.6 cubic kilometers and the lake extends upstream 380 kilometers to the Boghe-Cascas area. The dam was designed to support a water level more than 3.2 meters above sea level during extreme floods.

As of 1994, the lake's ecology had developed upstream as far as Dagana and perhaps Podor, but not as far as the Guede-Boghe area, which is the hydrologic limit of the lake when maintained at 1.5 meters above sea level. The change from a narrow, flowing river ecology, without shoreline vegetation and other aspects of a lake, had only occurred in the deeper part of Diama Reservoir, from the Dagana-Podor area and downstream. Although the backwater curve from Diama Dam may extend all the way upstream to Boghe, it may be many years before the lake ecology also extends that far upstream. This is important in describing the ecology and distribution of the bilharzia snails that have colonized the new Diama Reservoir.

The mean river flow at Diama Dam is about twice that at Manantali Dam, or 24 cubic kilometers per year. Thus the mean detention time in Lake Diama is four days at elevation 1.5 meters above sea level and nine days at 2.5 meters above sea level. It is thus a regulating reservoir in a delivery system, not a storage reservoir, and has highly seasonal flow characteristics based on the annual flood and on the demand of water users along the Lake Diama perimeter.

The operating level of Diama Lake is controlled by a coordinated schedule of water releases and spillway adjustments at both Manantali and Diama dams. The OMVS Coordination Unit t Rosso directs this operation on the basis of flows coming into Lake Diama from Manantali Dam and the Bakoye, Faleme, and Gorgol rivers, as well as the demands by users of Lake Diama water. They also base their decisions on tidal considerations downstream of Diama Dam. In general, Manantali Dam releases about 300 cubic meters per second, and the operating level at Diama Dam is maintained at 1.5 meters above sea level.

Lake Guiers

Lake Guiers, to the south of Richard-Toll on the Senegal River, previously collected rainfall from the Ferlo River sub-basin, but currently is filled by backwater from Diama Dam. The Taouey flow from Diama Reservoir reaches Lake Guiers through the enlarged and

Figure 11: Diama Dam was finished in 1987. It has formed a fresh-water reservoir over 200 kilometers long, seen here to the right of the dam. The flood gates were lifted to pass over 2,800 cubic meters of flow during the flood season of 1994.

Figure 11: Le barrage de Diama était terminé en 1987. Il a créé un réservoir d'eau douce de plus de 200 kilomètres de long qu'on voit ici à la droite du barrage. Les portes d'écluse ont été levées pour laisser passer plus de 2800 mètres cube d'eau lors des crues de 1994.

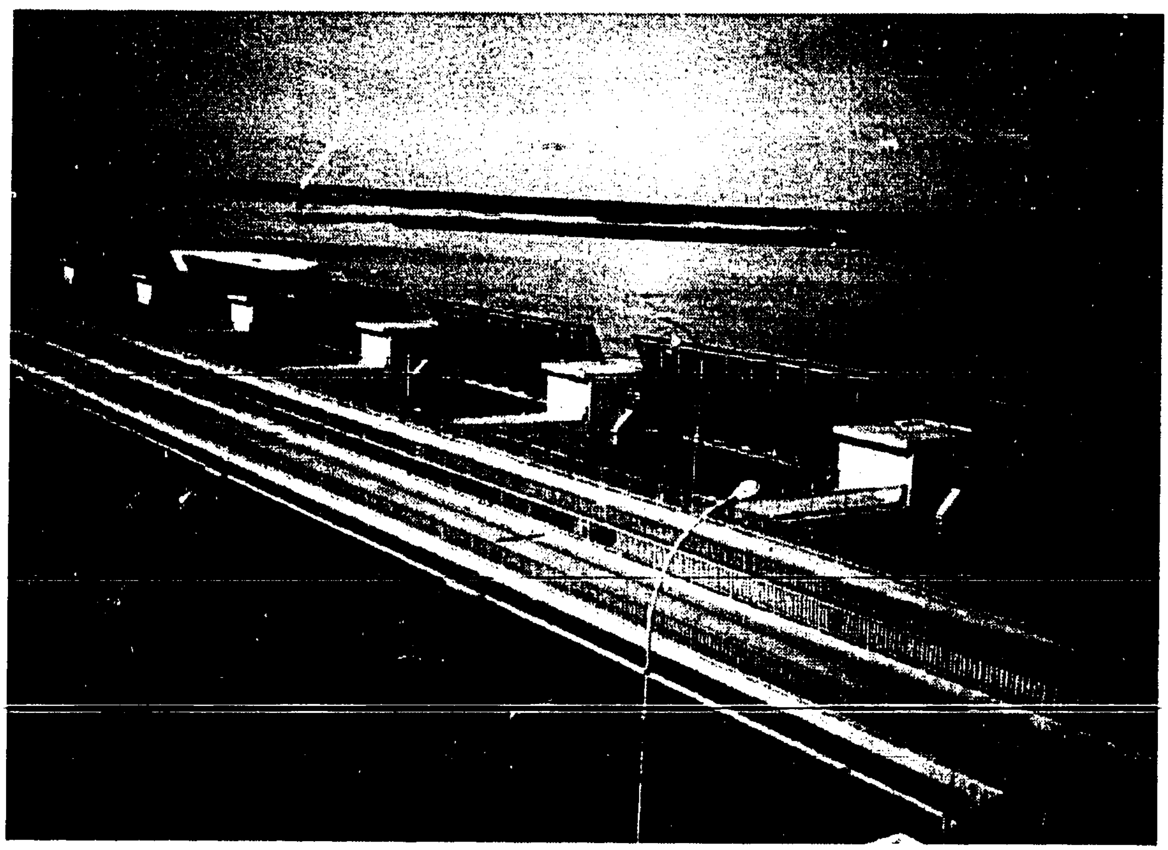


photo: Jobin

straightened Taouey canal. Since the construction of Diama Dam, the level and size of Lake Guiers has increased dramatically. The shore of the lake is becoming a center for irrigated agriculture. The lake is also an important resource for urban water supply.

Lake Rkiz

North of Rosso on the Mauritanian bank of the river, Lake Rkiz is a geographical extension of the depression that forms Lake Guiers. Now that Diama Dam has raised the level of the Senegal River, Lake Rkiz is being maintained at a more stable and higher level than in the pre-dam period. Similar to Lake Guiers, Lake Rkiz is also being developed as a source for shoreline agriculture. Water management is somewhat different, however. The shore around Lake Rkiz is being managed as a drawdown agricultural system, while at Lake Guiers irrigation is simply pumped.

Lake Aftout es Sahel

Near the ocean, north of St. Louis and north of the Mauritanian border, is a large depression that formerly filled with salt water during the dry season, but was flushed with fresh water during the Senegal River flood. Construction of Diama Dam eliminated this annual flushing with fresh water and destroyed the natural ecology, which supported great flocks of birds and other wildlife. To restore this depression to something approaching its natural ecology, a large outlet in the dike along Diama Reservoir has been constructed. Fresh water flow into Aftout es Sahel will be regulated according to ecological conditions.

Tidal Portion

The entire tidal portion of the river below Diama Dam is now almost completely marine because the annual flood of the river no longer takes place. This has caused a drastic ecological change.

Ocean Plume

The annual charge of sediment, nutrients, and fresh water formerly delivered to the coastal zone by the Senegal River flood has been largely eliminated. The mean annual discharge of fresh water was reduced by irrigation withdrawals and evaporation around Manantali, Gorgol, and Diama reservoirs, and most of the sediment is now being trapped in Diama Reservoir. This has caused a serious depletion in food and nutrients for the fish and other marine life along the coast.

Chapter 3: The Socio-Economic Factors and Conditions, Including Geography, Ethnic Groups, and Demography

In ethnic terms, the Senegal River Valley populations belong to several ethnic groups (by order of size): Toucouleur, Moor, Pular, Soninke, Malinke, and Wolof. Over half of the population is composed of Haalpular (Toucouleur and Pular). In the Middle Valley, the Toucouleur people are predominant and scattered between the villages of the alluvial plain and its neighboring fringe. In the Bafing River Valley, 95 percent of the population is Malinke. In the Bakel area, the villages are predominantly Soninke, while the Wolof people are to be found mainly in the Delta. In the Middle Valley, downstream from Kaedi, Moor and Pular people have traditionally moved their herds up to grazing grounds, spending the dry season in the valley and the rainy season in the sahelian fringes of the Middle Valley.

About 1.7 million inhabitants live in the whole Senegal River Basin; about 85 percent live near the river. The population growth rate (3 percent per year) is high. Since colonial days, emigration of the population has increased because of the demographic pressure in relation to the area's economic development. It is estimated that today, between 45 and 65 percent of the men migrate to Senegalese cities and to other countries in Africa and Europe. Apart from the effect of this migration on the labor force, another significant aspect is the foreign currency remittances these immigrants send back home.

The population moves a lot at the level of the valley itself. There is a "horizontal" movement along the valley on the one side, with the fishermen's seasonal movements, and the upstream (from Bakel and Matam) to downstream (towards Richard-Toll and St. Louis) movement in the search of job opportunities.

The valley's traditional socio-economic system comprises three interdependent activities: fishing, cattle breeding, and agriculture. Traditional agriculture is based on cultivation from rain and the river's annual floods. Traditionally, valley farmers have always farmed twice a year, once after the rains and a second time from the floods in the "oualo" on the river fringe. Given the decrease in rainfalls in the Upper Valley around the Delta, rain cultivation has always been more important in the Upper Valley, whereas farming during the period when the water level drops has always been more important in the Middle Valley and the Delta. Before the building of the dams, the annual floods inundated and fertilized about 400,000 hectares (in the average annual floods) in the alluvial plain. Fishing is practiced throughout the year. Cattle breeding is practiced by the Pular and the Moors, and practically all farmers are involved in sedentary cattle breeding.

Since the great drought in the beginning of the 1970s, the agro-pastoral socio-economic system has been dramatically changed, crops have strongly decreased, and the size of both big and small ruminant herds has greatly diminished. At that time, the river region experienced famines accompanied with malnutrition. It was that situation which motivated Mauritania, Senegal, and Mali to create the OMVS in 1972 in order to ensure water supply to the valley populations throughout the year and to allow for an integrated development of the river basin.

Chapter 4: OMVS Achievements

INTRODUCTION

The importance of the Senegal River as a resource for development of the countries in this sub-region was perceived very early, as the countries involved themselves individually in baseline studies and pilot projects. The first studies and field activities were activated by the Mission for Development of the Senegal River (MAS) created in 1948 and were especially concerned with the Delta and Lower Valley.

The creation of OMVS in 1972 was seen as the best way to prioritize economic objectives in basin-wide development of resources, to organize a concerted effort, and to reach agreement on common responsibilities for investment and management of the major works. OMVS has been created on the remains of the Organization of Riparian States of the Senegal River (OERS), which broke up because of political dissension between the countries. The objective of water regulation was to be realized through two essential approaches:

- The reduction of large fluctuations in the availability of water both seasonally and between years. These fluctuations endangered the food production systems, and thus threatened the survival of local communities.

- The control of flooding of the alluvial plain in order to agriculturally develop the water and soil potentials for self-sufficiency in food.

Regulation of the river was to be initiated as a multi-functional development of natural resources for irrigation, electricity production, and river transport. In a larger sense, it constituted an intermediate step toward sub-regional political and economic integration, and thus the creation of a zone for free exchange and the circulation of people and their goods.

This ideology of developing the basin for food self-sufficiency was consonant with the river's traditional use in the sense that local communities had already developed a local and diversified economy based on flood recession agriculture, fishing, and herding for local consumption. Even with these traditional forms of natural resource use, however, the best methods for joining of the valley into the national economic fabric were not at all clear in the beginning.

However, development of the Senegal River Basin was justified by the need for a change in scale from a local economy that exploited only a small part of the resources and remained strongly dependent on the vagaries of the climate, into a large-scale generation of agro-industrial production of rice and sugarcane aimed at meeting national needs. Thus, the production of rice was ~~emphasized as a national priority to reduce dependence of member countries on food imports,~~ which weighed heavily on the balance of trade.

MAJOR DECISIONS AND ACCOMPLISHMENTS

Basin-Wide Improvements

Before Independence

The first program for river basin improvement dates from 1935 when the Mission for Studies of the Senegal River (MEFS) was created. It was supposed to carry out projects oriented to agriculture, navigation, and hydro-electric power generation for Mali, Mauritania, Guinea, and Senegal. Its efforts lasted three years without concrete results.

The Mission for Development of the Senegal River was created in 1938 on the remains of the MEFS. MAS constructed irrigation basins at Guede and at Diorbivol near Podor for raising cotton. Then MAS proposed some large-scale projects such as the construction of a regulating dam about a hundred kilometers from Kayes. Because of financial and technical difficulties, this project was abandoned and replaced by a proposal for another dam located at Keur Mour near Dagana. Labor strikes stopped the activities of MAS.

Creation of the OMVS

After independence and in recognition of the poor results from sectorial policies for irrigated agriculture, the four countries started an integrated program of development entrusted to an Inter-Country Committee in 1963, which was replaced in 1968 by the OERS. Because of the divergences in views and preferences, and especially because of Guinea's lack of interest, the OERS was also dissolved. The three most interested countries, Mali, Senegal, and Mauritania, created the OMVS in 1972, which today is in charge of developing the river basin.

Development of Water Resources

The Delta Scheme

The option of constructing large-scale works to develop the water resources very soon found a favorable echo within the successive authorities. The first activities were directed to the control of flooding in the Senegalese Delta by the Toauey Dam, which isolated Lake Guiers, and by the construction of the left-bank dike from St. Louis to Dagana in 1964. These activities prepared the Delta lands for the irrigation of rice fields.

Faced with wide climatic variations, particularly periodic droughts that seriously compromised the supply of water by reducing the size of the annual river flood, the option of creating a fresh water reserve was compared with restraining the annual intrusion of the ocean. Thus, an earthen dam was maintained for several years at Rheuen, downstream of Richard-Toll, to permit the controlled filling of the Guiers and Rkiz reservoirs. Because this dam had to be rebuilt every year at considerable cost, the decision to build a permanent salt barrier at Diama was finally made.

Diama Dam has progressed to the optimal stage of operation after completion of the right-bank dike, which isolates the Mauritanian Delta from Diama Reservoir. The principal functions of Diama Dam, constructed 26 kilometers upstream of St. Louis and put into service in November 1985, are to stop the sea water intrusion, to create a storage reservoir of fresh water upstream of the dam, and to permit controlled filling of the reservoirs of Rkiz and Guiers.

The principal purposes of these first hydraulic works finished in the Delta were the reclamation of lands and the availability of water for irrigation. However, the real foundation for this program of river regulation was Manantali Dam, a project in the headwaters that regulates annual flood peaks to 2,500 cubic meters per second and sustains the dry season flow at 300 cubic meters per second. These management parameters have the aim of developing irrigation along with the other components of the OMVS program, namely electricity generation and navigation.

Manantali Dam

Manantali Dam on the Bafing River is situated 90 kilometers southeast of Bafoulabe and 1,200 kilometers upstream of the river mouth at St. Louis. The structure consists of a rock-filled dike 1,460 meters long, flanking a central concrete structure 493 meters long and 65 meters high. The spillway crest is at 208 meters above sea level and the average hydrostatic head on the turbines will be 40 meters. The elevation of the top of the concrete structure is 212 meters.

The reservoir created by the dam has a shoreline of about 150 kilometers. The volume of water retained at elevation 208 meters is 11.3 cubic kilometers, with a lake surface of 477 square kilometers. At the minimum operating level of the lake of 187 meters, the volume of stored water is reduced to 3.4 cubic kilometers with a surface area of 275 square kilometers.

The initial goal of irrigating 375,000 hectares of crops assigned to the dam may have to be lowered in view of the slow rate of development, far below expectations. Other functions consist in maintaining the dry season flow of the river at 300 cubic meters per second for navigation needs and producing 800 gigawatt-hours per year of electricity.

Considerable interest is focused on re-evaluating the operation of Manantali Dam at present because of difficulties encountered in the irrigation schemes regarding their profitability, and the prospects of diversification offered by electricity production and navigation.

National Irrigation Strategies

Political choices in the development of irrigation in the valley have influenced the options for water management and have contributed to making the state the principal actor in the agricultural sector. The high priority initially given to irrigation seems to have lost strength in the face of difficulties in structuring this sector and in retaining support of the OMVS to ensure a multi-sectoral operation of the major structures. In effect, the definition of sectorial policies is entirely the responsibility of the member countries; the OMVS occupies itself only with planning and developing the major structures.

Management by National Agencies

The two countries having the most irrigation potential have created agencies for agricultural development: SAED in Senegal and SONADER in Mauritania. The evolution of these two organizations has been fairly similar, with the following objectives:

- Irrigated development of land to increase agricultural production, essentially rice cultivation to absorb the growing food deficit

- Guidance in settlement of people in the zone and improvement in their standard of living

The countries soon gave an industrial and commercial character to these agencies. SAED organized the farmers into cooperatives, furnishing agricultural inputs and providing technical training. The agency took a strong role in collecting, transporting, and storing harvests. In addition, they secured credit for the farmers in the national banks by directly guaranteeing the control of profits at the time of marketing. The SAED monopoly on the marketing of rice gave them the means to fix prices for the producer.

The reasons for difficulties of these administrative agencies were caused not only by their organization and management structures, but also because of their poor technical management and problems with coordinating numerous activities. Over the years, the system became top heavy with apathetic personnel, unable to generate sufficient financial momentum to cover recurring costs.

The goals specified in the national policies on irrigation were to irrigate 375,000 hectares, including 240,000 hectares in Senegal; 126,000 hectares in Mauritania; and 9,000 hectares in Mali. In addition to progress significantly below expectations, the low yields (around two metric tons per hectare for the rice fields) constituted a discouraging factor in face of the exorbitant costs for developing and operating the fields (both for large projects and for small village fields).

After the Dams

After two decades of only partial successes, the simultaneous completion of the two structures at Manantali and Diama by OMVS in 1986 created a new dynamic that pointed to resource development, based on the integrated operation of the two dams. The maintenance of a permanent flow of water by Manantali and the raising of the water level by Diama has made pumping less costly for irrigation, and has reduced uncertainties in crop production. Also, this favorable situation developed at the moment that Senegal had resolved to reduce SAED and completely change its form.

The Mauritanian bank also underwent rapid transformation after 1990 with the proliferation of projects on the order of hundreds of hectares. This evolution was the fruit of efforts by private and trans-sectoral investors who seized the opportunity to exploit the lands left vacant in the aftermath of border disputes.

Revisions of the national policy in Senegal regarding the farming systems for rural populations came about largely because of failures in attempts with rice cultivation in the valley. The first large projects had been created and directed by national agencies with very high costs for construction and operation. The farmers, who saw the parcels and important mechanical equipment as properties of the agencies, were also left out of the planning process and management, even when it concerned the supply of water to the canals. The hydraulic systems consisted of electric pumps with main supply canals and secondary canal networks; SAED operated and maintained these systems to provide water.

In addition to the application of the water, SAED had also assumed the principal functions of management and maintenance of the fields. This absence of responsibility by the farmers was at the base of their disinterest in maintaining the basic works (e.g., pumping stations, irrigation canals, drainage network, and dikes). The problems encountered by the large projects favored the emergence of other types of development such as intermediate projects and village projects.

The village projects had lighter pump sets made up of a motor and pump mounted on a floating barge. This arrangement permitted the irrigation of some 20 hectares constructed in a simple fashion and thus at lower cost. The small investments and adaptation to local customs of voluntary cooperation, and the recognition of traditional land and water rights, contributed a great deal to the proliferation of the village projects despite their technical faults and the lack of careful planning. The major fault of the village projects is linked to the size of the parcels, which average 15 to 20 hectares, giving yields barely sufficient for subsistence of the farm families. This limitation on the cultivated area led to a search for a model in between the large projects village projects and the village projects.

The intermediate projects (or modular developments) are distinguished from the GP by the division of the cultivated area (on the order of a hundred hectares) into fields called autonomous irrigation units. This pattern of development was made possible by associating the farmers into producer groups centered around a revolving fund for purchase of equipment and other items.

Despite the success of the first modular project of Ndombo-Thiago, which had been an experimental trial of a model that was economically, socially, and technically reproducible, it seems that the current trends favor privatized development. The new private projects do not follow any established technical pattern but are based on the primary aim of reducing costs of construction and conform to the financial capabilities of the investors.

These technical innovations and directions in development strategies have not yet come upon a completely acceptable solution for the economic and social development of the valley. However, recent studies indicated that changes in social structure and patterns of management of the infrastructures are leading toward an integrated development of all available resources by careful management of the OMVS program. Specifically, the compromise adopted for the Master Plan of the Left Bank (PDRG) defined three levels of responsibility for management of the facilities:

- The first level concerns the basic infrastructures, such as the major river works and flood control structures. Their construction and maintenance are the responsibility of the state, as a public service.

- Collective facilities, such as canals and dikes, are the joint responsibility of the state and local communities.

- The terminal works, such as berms and the leveling of fields, are entirely supported by the private developers who own the land.

The energy and navigation components of the basin plan remain to be put into place and are composed of projects that offer the most likely possibilities of correcting the previously unsuccessful history of development in the valley.

The Energy Project

The Energy Project, for which the required financing was assured during the last meeting of the OMVS Council of Ministers in Bamako, will complete the facilities at Manantali Dam. The power plant will be equipped with five turbine-generator sets of 40 megawatts each, and a transformer and switching yard. The energy produced will be used mainly for supplying demand from the national capitals.

The Navigation Project

River regulation necessary for navigation was an integral part of the design study of Manantali Dam conducted in 1977-1978. Maintenance of a minimum flow of 300 cubic meters per second makes river transport possible up to Ambidedi in Mali, after the channel is cleared and rock sills in the Middle Valley are eliminated. The basic elements of the project have been modified according to reservations among the lending group about feasibility of the project.

The OMVS is conscious of the fact that justification of this project depends on developing the mining potential in the basin and introducing a transition system of ocean-river transport using barges. Some design changes that envision reductions in initial costs have been proposed:

- Establishing a terminal port at Ambidedi instead of Kayes

- Writing a new proposal on construction of sea and river ports at St. Louis

- Adopting an ocean-river system of navigation that uses shallow draft boats to link ports along the river with the seaports of Dakar and Nouakchott

Additional Projects

The OMVS program includes additional projects that are intended to complement the main works, with the aim of increasing the efficiency of water resource management. The projects will also contribute to increased profitability of the energy and navigation components. The principal components are groundwater monitoring, basin-wide mapping, and flow forecasting.

Groundwater Project

Within the Groundwater Project financed by USAID, a network of 600 monitoring wells was installed and reconnaissance was conducted to find village wells that could serve as control points. However, since the transfer of responsibility to the three member countries who do not have the means to collect the information, the network has not been monitored. OMVS is in the process of seeking funds to restart this project. Apparently the OMVS group in Mauritania is currently benefitting from international support to rehabilitate and monitor the wells in Mauritania.

Flow Forecasting Project

This project is involved with the collection of hydraulic data and their analysis using computer models developed in collaboration with the French research group, ORSTOM. The following objectives concern flow predictions:

- The prediction of quantities in Manantali Reservoir for proper management of the flows required in the river at Bakel
- The prediction of discharges in water courses upstream of Bakel for planning dam releases to meet the needs of downstream users
- The control of dam discharges aimed at adjusting reservoirs to meet expected demands
- Computer simulations of modifications of the artificial flood

Mapping of Potential Resources

This project has obtained aerial photographic coverage, installed benchmarks at seven satellite stations integrated into the geodesic network, and completed first-order leveling over 744 kilometers. These activities have not been entirely completed because of an interruption in financing that derailed the completion of the geodesic survey between Kayes and Bakel, the installation of benchmarks at Manantali and Yelimane, and the aerial coverage at 1:50,000 scale for the final 11 percent of the basin in the southwest of Mali and the southeast of Senegal.

RESOURCE MANAGEMENT AND THE ENVIRONMENT

Environmental Studies

Environmental assessment of projects being studied in OMVS development planning was made an integral part of feasibility studies between 1970 and 1980. Environmental requirements of lending agencies resulted in a study of OMVS by Gannett and Fleming in 1978, "Assessment of Environmental Effects of Proposed Water Resource Developments in the Senegal River Basin." The predictions contained in the Gannett report were not always verified in the field, especially in the realm of human health and the expansion of snail populations, which spread intestinal bilharzia to Lake Guiers and to the rest of the Delta. Despite these problems with the report, the objective of including environmental concerns in resource planning was attained.

Population Resettlement Study at Manantali

It is also important to note the studies undertaken in Mali, with the financial assistance of USAID, on the resettlement of populations because of the Manantali Dam's construction. The studies included a major emphasis on the collection of data necessary for completion of pre-construction and post-construction evaluations.

Monitoring Productivity in the Senegal River Basin

Efforts in this project financed by USAID were concentrated on understanding the systems of economic production at the family level in the Middle Valley. Data were collected and analyzed to serve decision-makers in the rational planning of resource development in the river basin. The final objective is to ensure long-term productivity of family activities, expansion of employment possibilities, and promotion of environmental stability. Rational planning of basin development requires a comparative evaluation of the advantages and disadvantages of various water management scenarios.

This study tried to determine the real value of the increase in income, employment, and environmental stability that would be generated by an artificial flood limited by water needs for power production and irrigation.

Despite conflicting viewpoints, the debate has concentrated on finding an intermediary position that permits optimal development of all the OMVS program components. The first experiences with provision of an artificial flood, the poor results with irrigated crops, and the improved understanding of the anthropology of riverine communities have certainly tipped the balance in favor of integration. Concerns about improving sanitary conditions in the populations also work in favor of coordinated research on a management model of multiple components.

Environmental Assessment of Manantali Energy Project

In 1993, an environmental impact assessment was undertaken within the Manantali Energy Project by the firm of Environmental Resources Management (ERM). In the course of the study, the concern for integration of environmental concerns in planning led to useful cooperation between the consultant and the project management on one side, and between the consultant and the planning engineers for the major works on the other side. Through this effort, modifications were made to the transmission line routes to avoid wetlands and faunal reserves in the Delta and in Mali.

The component for evaluating health impacts was given to Blue Nile Associates. Their report indicated the prevalence of intestinal and urinary bilharzia, rift valley fever, malaria, and changes in the nutritional status of riparian communities. Blue Nile Associates provided recommendations on operational techniques for managing the Manantali Reservoir to control the vectors of these diseases.

The Environmental Planning Component of OMVS

Management of the environment and health within OMVS is the responsibility of the Division of Development and Cooperation (DDC), which also coordinates development activities in the Senegal River Basin. Its latest activity report to the High Commission (February 1992) gave the status of the current activities on the following:

- A macro-economic study of the basin
- A Master Plan for mining, industry, and energy
- A study on environmental protection and ecosystem preservation in the basin
- A study on promotion of agricultural diversification and on production techniques
- Monitoring and evaluation activities; namely a data bank, guidance of development, teledetection, seminars, and interdepartmental cooperation

Despite budgetary constraints that limit the achievement of its objectives, the DDC continued the macro-economic studies and completed the mining part of the Master Plan for agro-industrial development. These final reports need to be continually updated. Also the completion of basin-wide environmental studies is underway; the Delta Project carried out by GDPA with FAC support was examined in the course of a seminar that took place in July 1994. Terms of reference for continuation of this project for the Middle and Upper Valleys are being revised. Other activities such as the geographic information system and the monitoring of irrigation projects by teledetection are presently underway.

Resource Master Plans

Three Master Plans are guiding development of the agricultural development of the basin. These plans concern the Left Bank, the Right Bank, and the Upper Valley.

The Left Bank Master Plan

Initiation of the planning process for the Master Plan of the Left Bank (PDRG) for Senegal marked a reversal in previous patterns in development planning, after repeated failures of several attempts at restructuring SAED. Following the elaboration of departmental master plans, the PDRG defined its political objectives as local and national food security, and improvement of the environment and living conditions in local communities.

The problem of development is centered on links between the economy, society, and the environment. The necessity for a compromise between the three spheres brought about the definition of five scenarios. Finally, a selection was made of the scenario that envisions maximum development of irrigation without putting in danger the use of water resources for the environment, drawdown agriculture, and hydroelectric production. Three application phases have already been started:

- The first transition phase (1992-1995) is being used for completion of baseline studies for future developments, in particular for improvements in the artificial flood.
- The second phase, that of construction (1996-2002), looks to the development of a prepared crop area of 53,000 hectares with a cropping intensity of 150 percent.
- Consolidation during the third phase, expected from 2003 to 2017, has as its objective 80,000 hectares at 160 percent cropping intensity and the harvest of maturing timber stands.

A Hydraulic Plan has also been developed for the Senegalese Delta to propose solutions to the poor flow connections along the Gorom-Lampsar route, following operation of Diama Dam. The PDRG has just been adopted as a planning document for the Senegalese part of the basin; the recommendations still must be put into effect.

The Upper Valley Master Plan

The objective sought in the Master Plan developed by Dames and Moore is to furnish a general framework for sectorial plans and to give broad directions for investments. An important portion of the development of the plan was the collection and analysis of data on the environment and natural resources. These data have been used to propose means for the improvement of infrastructure, principally transport, to eliminate isolation as a serious obstacle to development. The determination of geographic sub-regional units has been based on information from soil surveys and on social and anthropologic categories.

The institutional development part of the plan focuses on the training of the partners in development—namely village organizations, non-governmental organizations (NGOs), national organizations, and private developers—in the rational development of environmental potential.

Improvement in production systems with pilot trials using new or existing techniques is an objective in which the goals will include sustainable management of soil and environmental resources. The possibilities for developing irrigated agriculture are quite limited. More weight must be given to rain-fed agriculture, with the development of experimental irrigation trials in favorable zones.

CONCLUSIONS

The OMVS plays a major role in coordinating development of the Senegal River Basin and in promotion of integrated development. This zone contains resource potentials that are significant and susceptible to irreversible degradation. The actions of OMVS are especially oriented to designing, implementing, and managing the common works that serve to ensure regulation of the river and thus permit use of this natural resource. The efforts undertaken to integrate the environmental aspects have resulted in important studies and in the creation of a department responsible for the environment and for coordination. However, member countries have the responsibility for development planning in their own productive zones. This duality of responsibility between OMVS and the member states is at the base of the planning deficiencies and of the neglect of objectives in health, environment, and the wishes of local communities.

Chapter 5: Schistosomiasis, or Bilharzia

INTRODUCTION AND BACKGROUND

Schistosomiasis, or bilharzia, is a disease resulting from infection by one or more species of the trematode, *Schistosoma*. Infection occurs when larvae of the parasite penetrate the skin and enter the bloodstream. After a period of migration through the circulatory system and lungs, male and female worms mature and settle in blood vessels close to the liver, bladder, or intestines. Here they form permanent sexual pairs, enabling the females to produce large numbers of ova over the worm's normal lifespan of many years. The positioning, buildup, and host's cellular response to the eggs in and around abdominal or intestinal organs lead to varying degrees of disease.

The two main species of the parasite that exist in Africa, *Schistosoma mansoni* (intestinal form) and *Schistosoma haematobium* (urinary form), are endemic in the Senegal River Basin. Early symptoms of intestinal bilharzia include diarrhea and bloody stools. These are not always evident in light infections, and even when present are often confused with other ailments. But many complications can emerge from heavy infections and, if untreated, can lead to irreversible organ damage and even death. Blood in the urine is the main symptom of urinary bilharzia. In severe cases, there can be serious damage to the urinary tract, possibly leading to cancer of the bladder.

In addition to the human forms of infection, other species of the parasite are of veterinary importance. In the Senegal River Basin, one such trematode is *Schistosoma bovis,* which in many areas is highly prevalent in cattle. Each species of Schistosoma depends on a compatible species of aquatic snail to perpetuate its life cycle. In the Senegal River Basin, as in most of sub-Saharan Africa, the intestinal form of bilharzia can successfully infect only *Biomphalaria pfeifferi*, while the urinary form has evolved compatibility with different species of *Bulinus*. In the Delta, *Schistosoma bovis* appears to be reliant on *Bulinus truncatus*.

Before 1989, intestinal bilharzia was unknown in the Senegal River Basin of Senegal and in all of Mauritania. The disease had been reported in a few foci in Mali and in the Upper River Valley. The urinary form of the disease was present in all three countries. Apart from a few villages in Senegal, the prevalence was generally low in the Delta. The prevalence was higher in parts of the Middle and Upper Valleys, especially in communities near the river with irrigation networks and rain or flood-filled depression pools. Well-documented foci of infection included Podor, Matam, Bakel, Kayes, and Bafoulabe (**Figure 12**).

The epidemiological picture of the disease changed dramatically after the completion of the Diama Dam in 1986. Intestinal bilharzia reached Richard-Toll for the first time in 1988 and increased to epidemic proportions the following year. By 1993, nearly 100 percent of the residents of nearby Ndombo Village were found to be infected with heavy egg loads and, for the first time, many cases were reported on the Mauritanian side of the river (at Rosso).

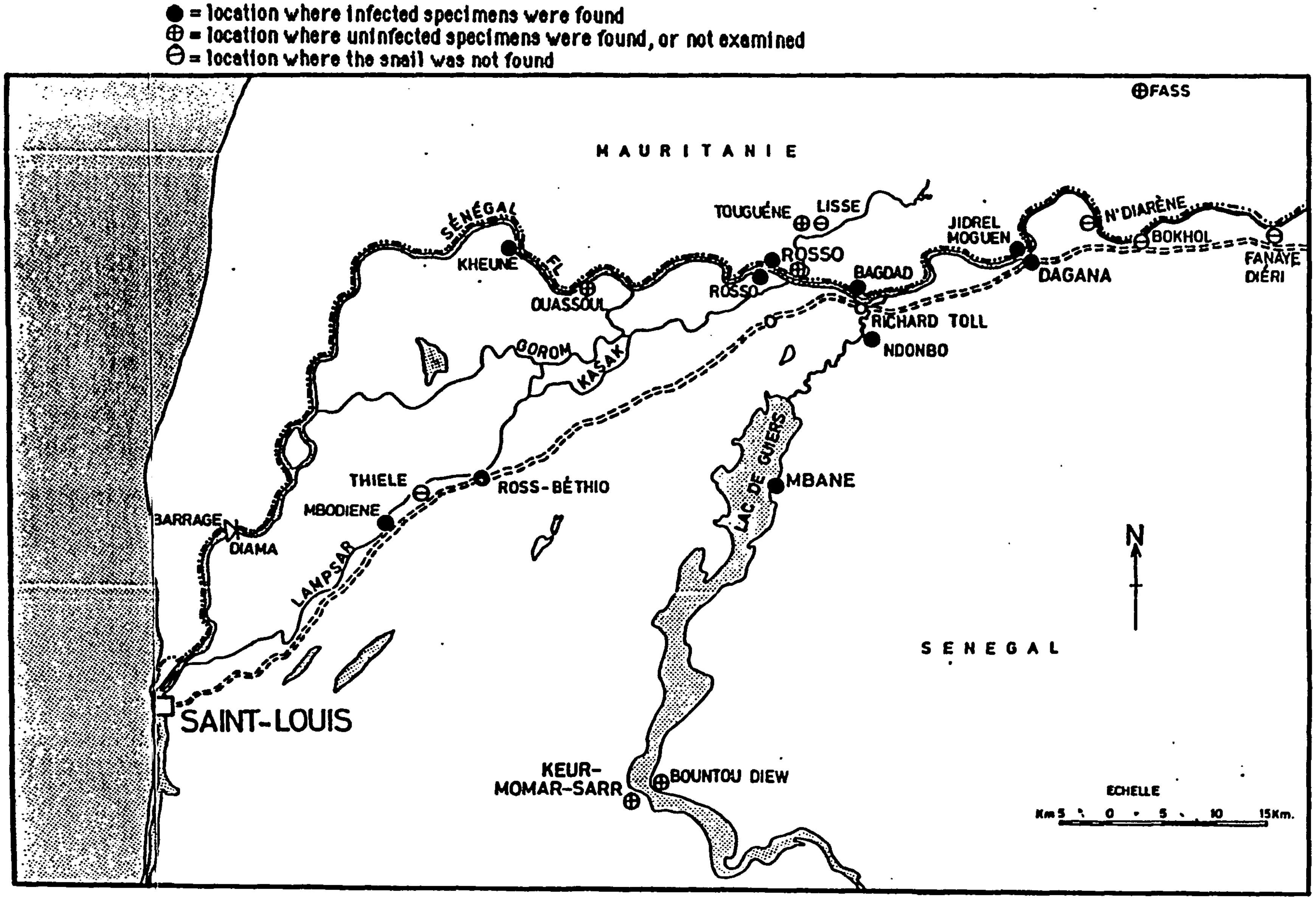


Figure 12. Area Surveyed for Bilharzia Snails in Lower Valley

Prevalence rates of *Schistosoma haematobium* also increased rapidly in the Delta after completion of Diama Dam, especially along the Lampsar River in Senegal.

The rise in prevalence and intensity of both species of bilharzia was a direct consequence of the completion of the Diama barrage and the upstream dam at Manantali. Although some experts correctly predicted the extension of bilharzia in the Senegal River Basin after the completion of the two dams, corrective action may have been neglected because one international team working under OMVS auspices clearly underestimated the disease threat when they concluded: "The transmission of bilharzia should not be modified .... No changes in the Delta are foreseen which would facilitate the productivity of the vector snail or larvae" (OMVS, 1982).

CURRENT FINDINGS

Epidemiological Survey

Selected primary schools (Senegal, Mauritania, and Mali) and fishing villages (Manantali, Mali) were sampled for *Schistosoma haematobium* and *Schistosoma mansoni* in parts of the Delta, Middle, and Upper Valleys. Except for two villages at Lake Manantali, urine specimens were screened for presumptive *Schistosoma haematobium* positivity with reagent dipsticks before filtration of the urine. Stool samples were processed and examined quantitatively using the Kato Katz technique (**Figure 13**). Collected data were compiled and analyzed through use of Epi-Info software. Following examination, all individuals found to be positive for either form of the disease were offered free treatment with praziquantel.

In the Delta, three schools on the Mauritanian bank of the river (**Figure 14**) were examined: at Rosso, Baghdad, and Jidrel Mohguen. For the first time, *Schistosoma mansoni* was confirmed in all three communities. Prevalence rates were 32 percent in Baghdad, 32 percent in Rosso, and 25 percent in Jidrel Mohguen (**Table 1 and Figure 15**). Egg counts in positive slides were generally low. In each village, the WASH/OMVS snail team found exceptionally high rates of infected snails (*Schistosoma mansoni* in *Biomphalaria pfeifferi*). The two sets of results suggested that a significant epidemic of intestinal bilharzia was taking place in that part of the Delta, one that was most likely in its early stages.

Prevalence of urinary bilharzia was significantly lower (Table 1). The rates were 12 percent in Rosso, 12 percent in Baghdad, and 11 percent in Jidrel Mohguen. The WASH/OMVS snail results complemented this. Few specimens of snail species known to be suitable intermediate hosts for *Schistosoma haematobium* were found in the villages. Although numerous *Bulinus truncatus* were found to be shedding parasites resembling *Schistosoma haematobium*, these were probable cercariae of *Schistosoma bovis*.

On the Senegalese side of the river, school children at Dagana (opposite Jidrel Mohguen) were screened for the parasites. The town is situated at the present interface between the easternmost limit of the man-made lake caused by the Diama Dam and upstream water still within the original river channel. Urinary bilharzia was absent, but the prevalence of *Schistosoma mansoni* was 47 percent, and positive egg counts were generally high.

Figure 13: Bilharzia survey in villages along the Senegal River. Registration of families in Baghdad near Rosso, Mauritania preceded examination of fecal and urine samples for diagnosis of bilharzia.

Figure 13: Enquête sur la bilharziose dans des villages le long du Sénégal. Inscription des familles à Baghdad près de Rosso en Mauritanie avant l'examen des échantillons fécaux et d'urine pour diagnostic de la bilharziose.

photo: Jobin

Figure 14: Lakeshore ecology of Diama Reservoir protects snails. Right bank just upstream of ferry crossing at Rosso, showing shoreline trash and vegetation which protected bilharzia snails from wave action and predators.

Figure 14: L'écologie des rives du réservoir protège les mollusques. Sur la rive droite juste en amont du bac traversant à Rosso, on peut voir des ordures et de la végétation qui protégeaient les mollusques à la bilharziose des vagues et de prédateurs.

photo: Jobin

Table 1. Prevalence of Bilharzia in Senegal River Basin from Surveys by WASH Team and National Working Groups in May, June, and July 1994

Location	Number People Examined	*Schistosoma Haematobium* Infections Urinary Bilharzia	*Schistosoma Mansoni* Infections Intestinal Bilharzia
Mauritania			
Region of Trarza			
Baghdad	96	12%	32%
Rosso School	59	12%	32%
Jidrel Mohguen	32	11%	25%
Lekseiba	100	8%	0
Region of Gorgol			
Mbout	100	2%	n.d.*
Region of Guidimakha			
Selibabi	205	33%	0
Senegal			
Near Richard-Toll			
Mbane	79	0	82%
Dagana	64	6%	47%
Mali			
Near Kayes			
Saboucire	79	15%	n.d.
Tombokan	90	86%	n.d.
Same Oulof	42	69%	n.d.
Same Plantation	78	97%	n.d.
Fishing Villages on Lake Manantali			
Mama Quanta and Djire Quanta	81	82%	14%
Villages Downstream of Manantali Dam			
Bingassi	50	72%	8%
Bamafle	71	49%	n.d.
Badioke	29	7%	n.d.

* n.d. means not done

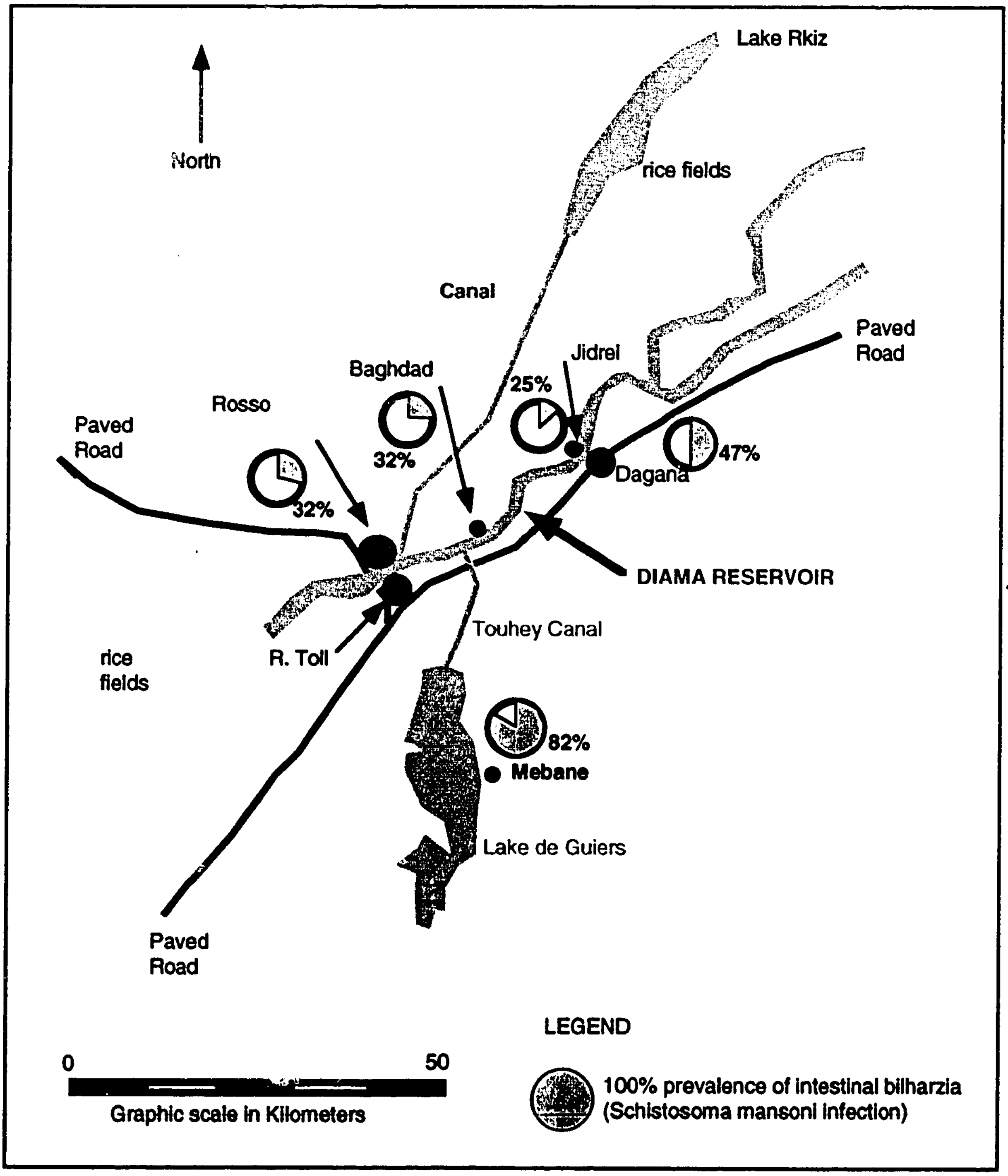


Figure 15: Map of Senegal River near Richard-Toll

Since the WASH/OMVS malacological team could not find *Biomphalaria pfeifferi* upstream from Dagana, it appears that Jidrel Mohguen and Dagana mark the easternmost limit for intestinal bilharzia in the Delta section of the Senegal River. This could change in the future if thicker emergent vegetation takes root upstream.

The WASH/OMVS team examined school children at Mbane, which is located on the eastern shore of Lake Guiers. Earlier results from the epidemiological center at Richard-Toll indicated that intestinal bilharzia was more than 70 percent at Ngnith, on the western shore. Our present findings revealed that the Mbane children had an overall prevalence rate of 82 percent (Table 1). More alarming was that the egg counts were extremely high. This corresponded with the large numbers of infected *Biomphalaria pfeifferi* found by the WASH/OMVS snail team in lakeside water contact sites of Mbane. Although no urinary bilharzia was detected in the school children, uninfected *Bulinus globosus* were collected in two locations just north of the village. The snail is an ideal host for *Schistosoma haematobium*. Increased irrigation with open canals and drains on the eastern shore could therefore lead to the establishment of the urinary form of the parasite.

Neither the WASH/OMVS team nor previous investigations found evidence of *Schistosoma mansoni* in the Middle Valley. Urinary bilharzia remains endemic, however, although its current distribution has been less affected by the Diama and Manantali dams than in the Delta or Upper Valley. Our examination of school children at Mbout (near the man-made lake of Foum Gleita) revealed a *Schistosoma haematobium* prevalence rate under 5 percent. Another recent survey of children at Salibabe by Malian health authorities indicated a prevalence of 33 percent. Urinary bilharzia along the Gorgol River in Mauritania has long been endemic. At present, the infection is low in the Foum Gleita irrigation basin. The network of canals below the dam has been kept relatively weed free, and most sections of the man-made lake behind the dam appear unfavorable for heavy snail infestation.

The Upper Senegal River Valley is presently in a state of ecological flux following the operation of the Manantali Reservoir. Intestinal bilharzia is becoming a problem in villages along the lake shore, and the prevalence of urinary bilharzia in the area is high in many locations (**Figure 16**). Two fishing villages on the eastern shore of the lake were surveyed quantitatively by the WASH/OMVS team. In the first village, Mama Quanta, the prevalence of urinary and intestinal bilharzia was 80 percent and 14 percent respectively. In the second village, the respective results were 84 percent and 14 percent. The egg counts of *Schistosoma haematobium* were low to moderate. Of 81 specimens examined in the two settlements, 13 showed egg densities greater than 50 per 10 milliliters of urine. Three other villages were surveyed in a short stretch of the Bafing River immediately downstream from Manantali town (Table 1). The prevalence of urinary bilharzia ranged from 72 percent at the upstream end (Bingassi), 49 percent in the middle section (Bamafle) and 7 percent in the downstream spot (Badioke). Of these three villages, intestinal bilharzia was found only at Bingassi (8 percent prevalence).

At the request of the WASH/OMVS team, three additional villages that had been resettled near Manantali were screened for *Schistosoma haematobium* by the Mali Scientific Working Group. This team recorded overall prevalence rates of 69 percent, 85 percent, and 95 percent.

Figure 16: Manantali Lake in western Mali. The lake filled to spillway level in 1992 *(a)* and was soon colonized by fishing cooperatives from the Mopti region of Mali *(b)*.

Figure 16: Lac Manantali à l'ouest du Mali. En 1992, le lac était sur le point de déborder *(a)* et a été r.pidement colonisé par des coopératives de pêcheurs de la région de Mopti au Mali *(b)*.

(a)

photos: Gregory Leeds

(b)

Malacological Survey

Details of the villages surveyed, dates of sampling, methodology, and specific snail findings are presented in an annex to this report on bilharzia. The main highlights of the WASH/OMVS snail survey are summarized as follows.

The snail host of intestinal bilharzia, *Biomphalaria pfeifferi,* was discovered for the first time in Mauritania. It was widely distributed along the north bank of the Senegal River from Rosso to Jidrel Mohguen, and showed high rates of infection with *Schistosoma mansoni* (Figure 17). The snail was also found to be spreading further north: in the Garak canal at Tougene, and in the Sokam canal at Fass (not far from Lake Rkiz).

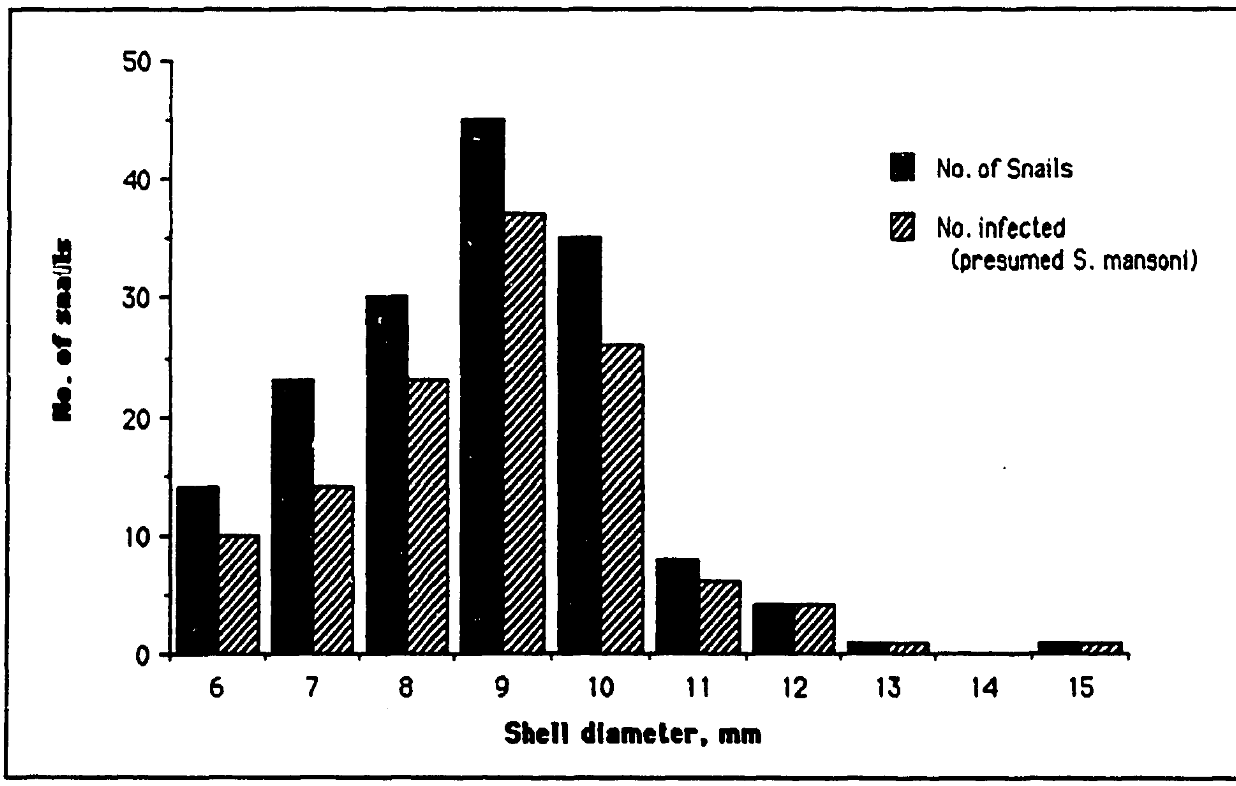


Figure 17: Size and Infection Breakdown of *Biomphalaria pfeifferi* from a Sample of Snails Collected

On the Senegalese side of the river, *Biomphalaria pfeifferi* was found in large numbers from Kheune in the west to Dagana in the east. The snail was widely distributed around Lake Guiers, in the Taouey canal near Richard-Toll, and in the Lampsar River. This is the most widespread distribution of the snail ever reported in the Delta. In all but two locations surveyed where the snail was found, infection rates with *Schistosoma mansoni* were extremely high.

Upstream from Dagana to Kaedi, Mauritania, *Biomphalaria pfeifferi* was absent from all six communities inspected along the Senegal River. Unlike Lake Diama, with calm water and heavy marginal weed growth, this long section was distinctly riverine, largely within the original river channel, with little or no emergent vegetation growing on either bank.

Numerous shells and a few living specimens of *Biomphalaria pfeifferi* were found around Lake Manantali, Mali (**Figure 18**). This is confirmation that the snail has infested this new ecological niche and will expand there in the future (as in Lake Diama) if the lake's water level is not allowed to fluctuate significantly. The dead snails that littered the shoreline in July 1994 were most likely killed by deliberate reductions in lake level that were intended for other purposes. The lake level dropped from an elevation of 194 meters on May 18, 1994, to 192 meters on July 18, 1994, a mean vertical recession rate of 3.3 centimeters per day.

For the first time, *Bulinus globosus* (an important snail host of urinary bilharzia) was found at Lake Guiers, in canals a few meters from the lake shore. The same snail was found in the Lampsar River at Mbodienne and Ross Bethio, where collected specimens were heavily infected with presumed *Schistosoma haematobium*. Another specimen resembling the species was found at the Bafing River near Lake Manantali.

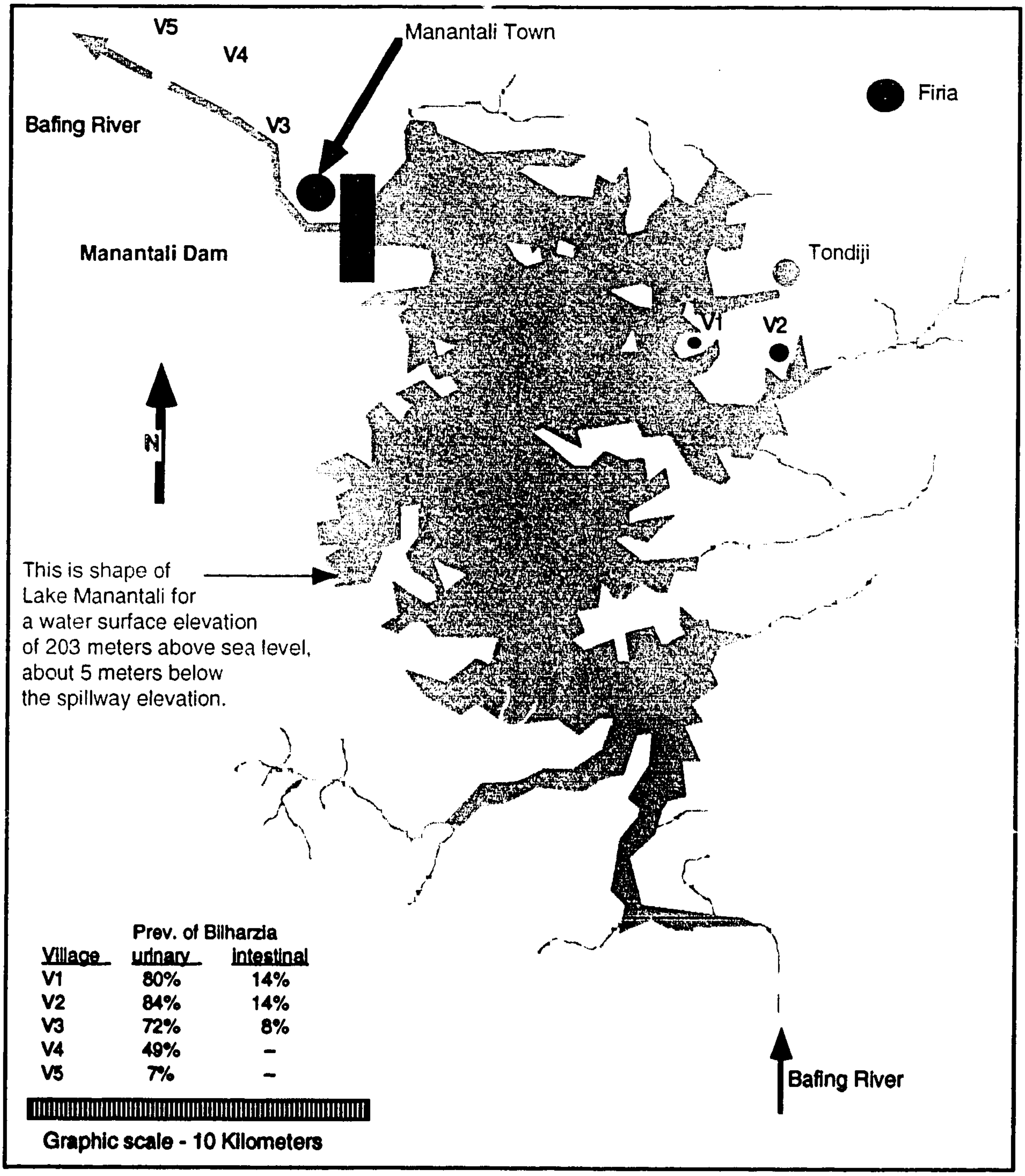
Bulinus truncatus, the host of *Schistosoma bovis* in the Delta and *Schistosoma haematobium* in other parts of Africa, was found in most locations surveyed. Both Mauritania and Senegal showed evidence of infection with brevifurcate cercariae, either *Schistosoma haematobium* or *Schistosoma bovis*. The same type of cercariae appeared in some *Bulinus forskalii* collected in the Delta of both countries. However, the total number of these snails was low.

Searches for another intermediate host of urinary bilharzia, *Bulinus senegalensis*, were made near the Lampsar River in the Delta and Guedi Chantier in the Middle River Valley.
No living specimens or shells were found. Guedi Chantier was once a major rice growing village and a known focus of *Schistosoma haematobium* transmitted through the snail. The abandonment of water-dependent rice cultivation in favor of drier tomato farming led to the die-back of the snail and the parasite (the annex on snails gives a more detailed report on snail sampling).

The Foum Gleita irrigation network was relatively free of bilharzia snails. Although some *Bulinus truncatus* were found in canals near the dam, conscientious manual labor has kept most of the canals free of weed growth. The level of the man-made lake behind the dam has been dropping over the past five years, and the relatively flat topography of the lake basin allows for tremendous horizontal fluctuation of the drawdown area, an ecological dynamic that has prevented snail infestation.

Conclusions

It is clear that the Diama and Manantali dams have transformed the Senegal River Basin into an ecosystem that is exacerbating the proliferation of urinary and intestinal bilharzia. The team has observed this in the stable man-made lakes and non-fluctuating rivers, the mushrooming irrigation canals that are infested with weeds and vector snails, and in the



	Prev. of Bilharzia	
Village	urinary	intestinal
V1	80%	14%
V2	84%	14%
V3	72%	8%
V4	49%	-
V5	7%	-

Figure 18: Prevalence of Bilharzia in Residents around Lake Manantali

human populations that are rapidly expanding to benefit from opportunities in agriculture, trade, and fishing. This is not surprising considering the fact that all large dams in endemic areas of Africa have increased the endemicity of bilharzia, both in the man-made lakes behind the dams and in the irrigation networks that feed off them.

The main environmental reasons for the increase in intestinal bilharzia in the Delta were two-fold: the elimination of salt water that formerly controlled dry season weed growth and vector snail populations in the main river, tributaries, and irrigation canals; and the stable water levels that resulted from the releases from the Manantali Dam. This synergism allowed the snails to maintain large populations during many months of the year and to expand in new ecological niches. The well-documented epidemic of intestinal bilharzia at Richard-Toll is a consequence of this, the large human population, and the combined effect of inadequate fresh water supply and sanitation.

The WASH/OMVS survey on the Mauritanian side of the river in the Delta revealed that an epidemic of intestinal bilharzia has begun in riverside communities and, without meaningful intervention, will most likely increase to higher levels.

At present, intestinal bilharzia is a serious problem in all riverside communities from Diama Dam upstream to Dagana. Whether this infection will spread further upstream from Dagana in the main river channel will large depend on future aquatic weed growth along the river bank. At present, there is little dry-season vegetation upstream to Kaedi, a condition that is unfavorable for the rapid spread of the infection into the middle sections of the Senegal River. However, the WASH/OMVS snail survey discovered the vector snail of intestinal bilharzia in canals leading north from the Rosso area of Mauritania to the Lake Rkiz basin.

Urinary and intestinal bilharzia will probably become a serious problem in many of the irrigation networks that are expanding in the Delta and Middle Valley sections, especially where rice and sugar cane will be the main crops. But the example of Guedi Chantier shows that transmission of bilharzia can be reduced or eliminated by changes in irrigation practice and crop selection.

The bilharzia threat in and around Manantali Dam was documented by the WASH/OMVS team. While urinary bilharzia is a serious problem behind and below the dam, there is circumstantial evidence that *Biomphalaria pfeifferi,* and hence, transmission of intestinal bilharzia, can be controlled along the lake's perimeter by periodic fluctuation of the water level (**Figure 19**). Although transmission was probably intense during the months of the year when the reservoir was relatively stable, the steady recession from January 1994 to July 1994 stranded almost all of the snails.

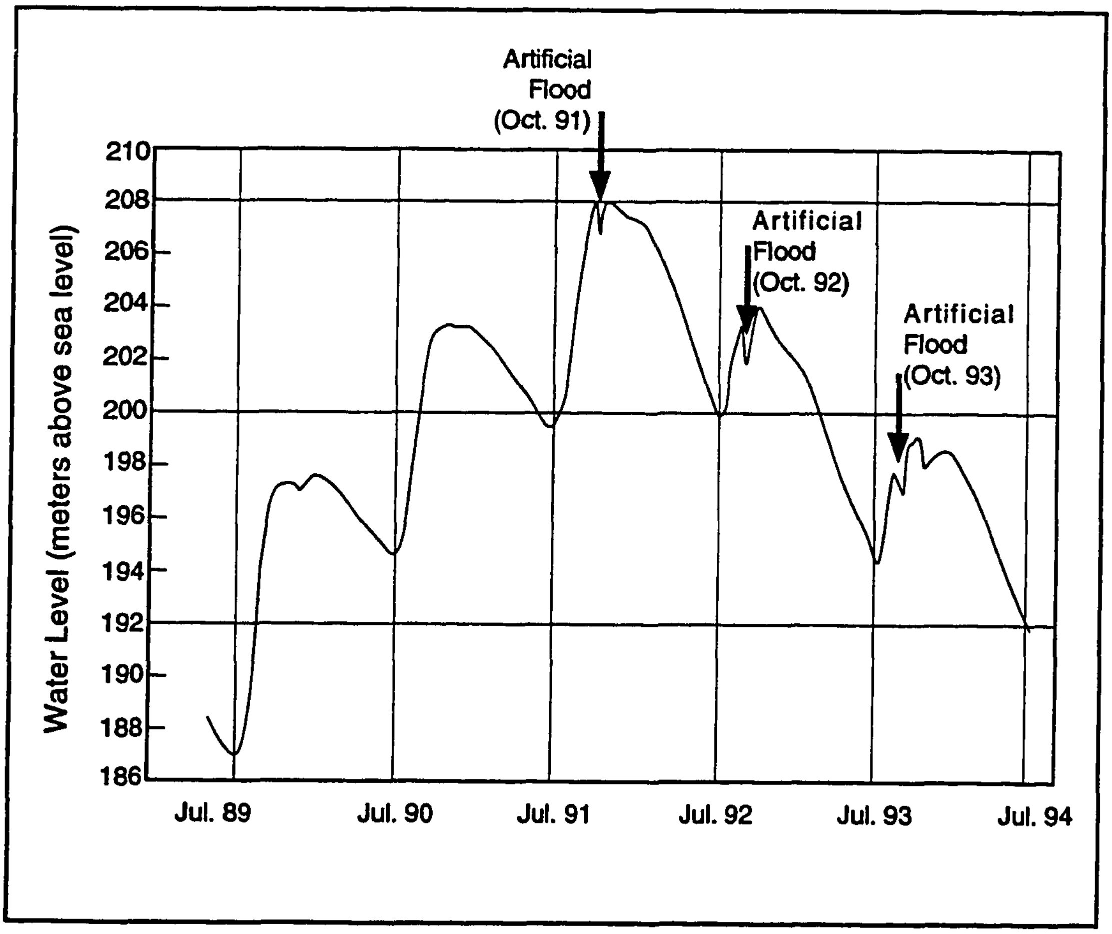


Figure 19. Annual Fluctuations of Water Level in Manantali Reservoir

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Chapter 6: Malaria

INTRODUCTION

Malaria occurs in most parts of the Senegal River Valley. Virtually all reported infections are due to malaria tropica *(Plasmodium falciparum)*, which can cause severe disease and mortality. Transmission used to take place mainly at the end of the rainy season and the beginning of the dry season, the period when the malaria mosquitos *(Anopheles)* reach their peak biting density. Because mosquitos depend on rainfall, the risk of infection with malaria increased upstream (from about 200-300 millimeters annually in the Delta to more than 450 millimeters in Bakel). Transmission was unstable and probably not sufficient in the drier areas to maintain immunity in the population. Severe epidemics affecting all age groups occurred when conditions for transmission became favorable.

In eastern Senegal, the most important species of malaria mosquito *(Anopheles gambiae)* breeds in small, shallow collections of water well exposed to sunlight, such as pools formed by rains, paddy fields, and seepages from irrigation water and water-filled depressions and man-made pits in dry river beds. Changes in the environment because of stabilization of the river water level after the construction of the Manantali Dam in Mali and the Diama Dam near St. Louis in 1986-1987 are likely to have had an effect on the ecology of the malaria mosquito and therefore also on the period and intensity of malaria transmission.

Systematically collected and microscopically confirmed data on malaria transmission are not available from the health services in the region. Evaluation of trends in malaria transmission is therefore very difficult. The Department of Public Health of the Region of St. Louis reports malaria as the most important cause of reported morbidity with a total of 35,972 clinically diagnosed (i.e., not microscopically confirmed) cases in 1993. It is believed that the number of malaria cases is increasing as a result of an increase in irrigation.

Research on malaria in the region has remained minimal and is limited to a few longitudinal studies in the Middle Valley, in the department of Podor. Another longitudinal study was begun in a village in the Delta in early 1993. In addition, point prevalence data are available for a number of places along the river.

METHODOLOGY

To provide information and recommendations for the OMVS Health Master Plan for the valley, we have relied on two methods:

- Evaluation of available data from health centers, discussions with health personnel, reports, and research articles.

- Field collection and examination of blood smears; collection of adult, indoor resting and biting mosquitos; collection of *Anopheles* larvae; and identification of breeding sites. The timing of our visit to field sites, from May 12 to 26 in Senegal and

Mauritania and from July 15 to 23 in Mali, did not allow us to make observations during the peak transmission season from July to October and November.

RESULTS

Most of the surveys, as well as our own data, give a picture of light malaria transmission (hyper- to meso-endemic) in the Delta and Middle Valley, varying from year to year, and highly seasonal with the highest risk of infection during and after the rainy season (August to December). Because of higher rainfall and a consequently longer transmission season, the risk of infection with malaria is highest (hyper-endemic) in villages in the Upper Valley, in Mali.

From the information obtained during our visit, it is hard to draw any clear conclusions on the effects on malaria transmission caused by the recent hydrological and subsequent agricultural and socio-economic changes in the Valley of the Senegal River and some of its tributaries (e.g., Gorgol and Rkiz). The studies in Kasak-Nord and near Podor and the unpublished OMVS study in 1991 throughout the whole valley suggest that in spite of increased mosquito densities, including increased densities of the malaria mosquito, *Anopheles gambiae,* in the Middle Valley, there is no significant increase in malaria because of the introduction of irrigated rice fields. One reason for the lack of an increase in malaria could be increased self-protection with mosquito nets by people living close to irrigated fields. Because domestic animals are often kept near the house during the night, the mosquito nets may have diverted hungry mosquitos to unprotected animals. These observations are more or less confirmed by studies in rice-growing areas in Vallee de Kou in Burkina Faso.

However, contrary to the studies cited above, the health services in Rosso, Richard-Toll, and Podor provide data which suggest that malaria transmission is now more common, even during the dry season. This is in clear contrast to results from the studies in the Senegal River Basin discussed above. The data from Boghe and Podor clearly suggest a relation between the occurrence of malaria cases from December to April and the irrigation of fields for a second crop of rice. Although most of the reported malaria cases have not been confirmed microscopically, evidence seems strong enough for a prolonged transmission season beyond the traditional wet season peak. The continuation of transmission is mainly due to the availability of suitable breeding sites in irrigation systems in the months following the rainy season and may sometimes last until the end of the dry season.

To explain the discrepancy with the studies near Podor, it should be taken into consideration that such detailed longitudinal studies provide valuable information on only one small study area (the village of Diamandou). It is not known how valid their results are for the rest of the valley or even its immediate surroundings. Data collected in another study in the immediate vicinity of Diamandou and during the same period show much higher prevalence rates and continued transmission of malaria during the dry season for villages bordering irrigated rice fields.

In spite of large surfaces of (perennially) irrigated fields, malaria does not seem to be an important public health problem in the Delta. The longitudinal study in Kasak-Nord shows the almost absence of the most important malaria mosquito *(Anopheles gambiae),* and dominance of another species *(Anopheles pharoensis)* that is less effective as a vector of malaria. The high salt content of the soil in the Delta has been suggested as an explanation. However, rainfall in the Delta is also considerably less compared to that of the Middle Valley. If these explanations are valid, an increase in malaria transmission should be anticipated for years with higher rainfall or after the salt has been washed from the soil by the flow of fresh water.

Our own collections in Baghdad, east of Rosso, confirm the dominance of the *Anopheles pharoensis* mosquito species in the Delta, at least during the dry season. Malaria cases were detected in May, however, suggesting that transmission during and after the wet season will be considerable.

The high prevalence of malaria observed in Mali, in the villages located around the lake and downstream from Manantali Dam, should be carefully interpreted in terms of its link with the hydraulics of the river and the dam.

PREVALENCE OF MALARIA

According to the 1993 annual report from the Department of Health in the Region of St. Louis, Senegal, there were 36,000 cases of malaria in 1993, the largest number of reported cases for any single disease. About 4,000 of those cases were in children under one year of age. According to the same report, malaria has become more prevalent after the extension of irrigation systems.

Results from the WASH team survey, made during May, which is the dry season when there should be little malaria transmission, included measurements of splenomegaly that indicate past malaria infections. The normal malaria transmission season is from November to February, thus the observed prevalence of disease was probably much lower than the high prevalence expected following the rainy season in November.

During the May 1994 surveys, about 4 percent of the persons examined had *Plasmodium falciparum* parasites in their blood, and 6 percent had detectable splenomegaly (Table 2). In Foum Gleita, a parasite rate of 28 percent had been detected in 1993, probably right after the rainy season (Teuw and Lan Thierno, 1993). This confirmed the reports of local health authorities that malaria prevalence was quite high.

Table 2. Indications of Malaria among Children Surveyed in Mauritania during May 1994

Village	Blood Slides Examined	Malaria Parasites Observed	Splenomegaly Measured
Baghdad	94	1	5
Rosso-Ndioubel School	67	4	6
Jidrel Mohguen	62	4	2
Totals	**223**	**9 = 4%**	**13 = 6%**

In the Kayes Region of Mali, malaria was reported more often than any other water-associated disease (Table 3). The cases recorded as malaria were diagnosed as fever with convulsions and also fever without other symptoms. Thus, the cases may have included other diseases including cases of diarrhea, which was the second most common disease.

Table 3. Cases of Water-Associated Diseases Reported by Health Service Facilities in Kayes Region of Mali in 1992 (Statistical Yearbook, Department of Statistics, Ministry of Health, Mali, 1992)

Disease	Number of Cases Reported in 1992
Diarrhea with dehydration	1,424
Diarrhea without dehydration	5,768
Fever with convulsions	917
Fever without other symptoms	31,482
Urinary bilharzia	4,513
Intestinal bilharzia	67
Guinea worm disease	176
River blindness	349

Results from the July 1994 WASH survey around Manantali Lake in western Mali revealed higher parasite and splenomegaly prevalences than those observed in Mauritania during May. In the five villages surveyed, the prevalence of *Plasmodium falciparum* parasites in blood slides varied from 14 to 47 percent. The prevalence of splenomegaly varied from 2 to 11 percent in these same villages (Table 4).

Table 4. Indications of Malaria among Children Surveyed around Lake Manantali in Mali during July 1994

Village	Malaria Parasites Observed	Splenomegaly
Mama Quanta	14%	8%
Djire Quanta	47%	
Bamafale	30%	11%
Bingassi	27%	
Badioke		2%

GENERAL CONCLUSIONS

- There is a great variability between villages in factors influencing malaria transmission.
- The risk of infection with malaria increases when traveling upstream along the Senegal River.

- Villages in the Middle Valley located next to rice fields that are irrigated throughout a large part of the year probably have a longer malaria transmissi‹ ı season than the usual peak during and shortly after the rainy season.

- Mosquito nets are commonly used by people living close to irrigated fields; in combination with widespread availability of domestic animals, these nets may be effective in diverting malaria mosquitos from humans to the animals.

- Accessibility and use of malaria treatment (chloroquine) may have increased in (some) irrigated areas as a result of improved infrastructure and prosperity.

- The stabilization of the river water level following the construction of the dams prevents breeding of malaria mosquitos in pools in the river bed during the dry season. This would have reduced transmission in villages located within two kilometers from former breeding sites in the riverbed. However, the presence of vegetation and irrigated fields around houses during the rainy season has created conditions of a seasonal burst of malaria downstream from the dam. Furthermore, there seems to be malaria endemic situation around the lake, which has to be confirmed by further epidemiological and entomological data collection over a longer time.

- The continuing continental decline in the amount of annual rainfall may reduce malaria transmission, especially in relatively dry areas without irrigation (**Figure 20**).

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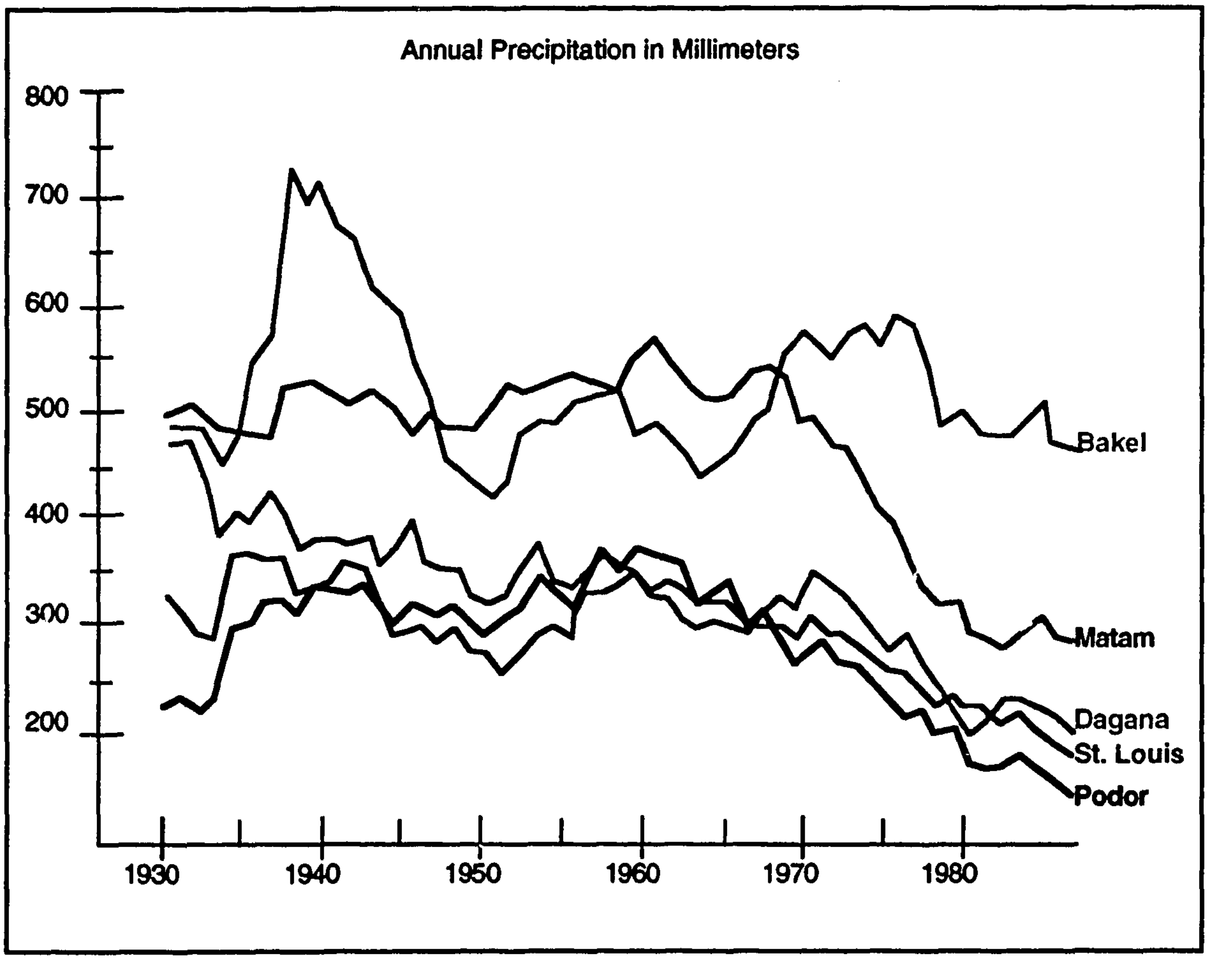

Figure 20: Historical Decrease in Rainfall Since 1930

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Chapter 7: Agriculture, Household Food Availability, and Nutritional Status

Following years of drought and famine in the Senegal River Valley, it was expected that the construction of the dams and the development of irrigated agriculture would serve as a catalyst for economic development and significant improvements in the socio-economic status of the valley inhabitants. Unlike the period before dam construction, the presence of the dams and the stabilization of the water level in the Senegal River ensure the availability of water on a year-round basis. Greatly increased water availability has made possible the dramatic expansion of irrigated agriculture, expansion of certain agriculture-related businesses, and the year-round use of water for household and other purposes. Some thought that such economic development would, in turn, contribute to improvements in the nutritional and health status of local inhabitants. This study assessed the effect that the construction of the dams in 1986 and 1988 has had on the health and nutritional status of river valley communities.

Scope of Analysis and Methodology for Data Collection

Since 1988, numerous factors have contributed to the health conditions of river valley communities. These factors include economic, environmental, socio-cultural and political variables; some are related to the construction of the dams while others are not. The economic factors are related on one hand to the agro-sylvo-pastoral production system within the valley and on the other, to the significant out migration of labor and the substantial remittances consistently transferred back into the valley. The environmental factors include the construction of the dams themselves, changes in water management because of the dams, and the continuous decrease in rainfall in the area since 1970. The socio-cultural factors include the roles, habits, and survival strategies of the ethnic and socio-economic groups in the river valley. The political factors include the national agricultural, health, and water/sanitation policies of Senegal, Mauritania, and Mali; and the relationships between the three countries, which can influence the agro-sylvo-pastoral activities of river valley inhabitants. No one set of factors is sufficient to explain the changes in health and nutritional status. Rather, the combined effect of these factors has contributed to present conditions.

A comprehensive assessment of the changes in health status on the part of river valley communities should, therefore, take into account all of these factors. The development of the methodology for this component of the larger study was based on a systems approach. **Figure 21** outlines the factors that were hypothesized to relate to the health and nutrition of river valley communities. The factors in the diagram were possible to investigate in the time allotted for the study. The variables in the diagram deal with the production system and the physical environment. These factors are not intended to be exhaustive; however, they are believed to be the factors that have contributed most to changes in health and nutritional status.

Our objective was to assess changes in each of these factors since 1988. Ideally, for each of the variables included in the systems model, the situation before and after dam construction

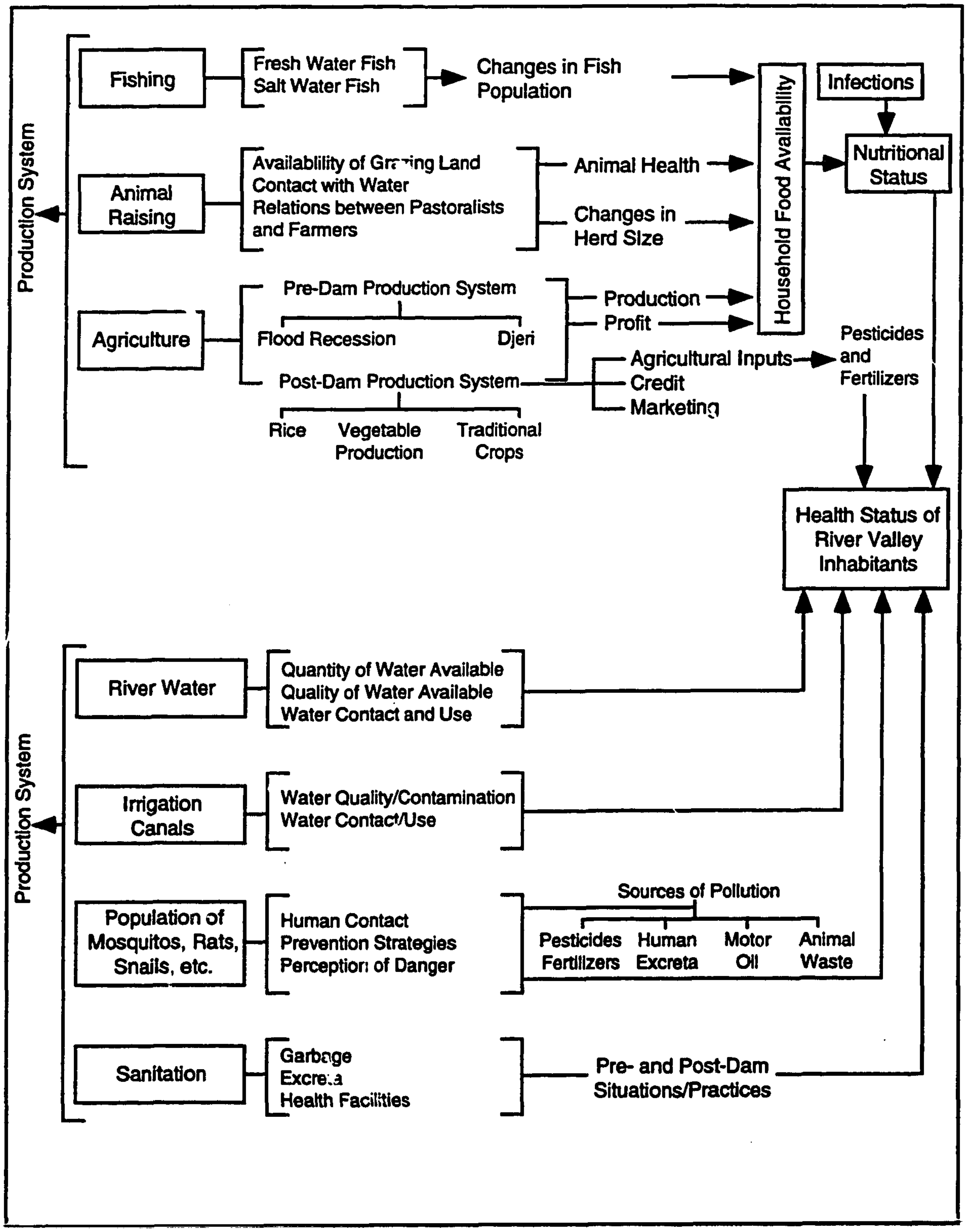


Figure 21. Socio-Economic and Environmental Effects Related to Health and Nutrition in Senegal, Mauritania, and Mali

should have been compared. Unfortunately, comprehensive and reliable pre- and post-dam construction data were not available on most of these variables. For this reason, it is difficult to precisely assess changes in the environmental and socio-economic variables, as well as in health and nutritional status. Given this major constraint and the limited time available for conducting the study, our work consisted of synthesizing the existing statistical data; conducting in-depth interviews with institutional actors from the agricultural and health sectors involved in river valley development; carrying out observations of water, sanitation, and farming conditions at the community level; conducting in-depth interviews at the community level with a total of 191 persons (56 in Mali, 94 in Mauritania, and 42 in Senegal); and collecting anthropometric data on women and children in four Mauritanian villages involved in rice-farming.

This discussion deals primarily with developments on the two banks of the Senegal River in Mauritania and Senegal. Along the river, dramatic changes in the production system and subsequently in the socio-economic conditions of local communities have come about in the last decade. Many commonalities exist between the two countries. The Mali villages, which were resettled before the filling of Manantali Reservoir, and the fishing villages around the lake are also discussed. Irrigated agriculture has not yet been introduced along the Bafing River in Mali; therefore, changes in the production system have been less radical. However, extensive irrigated areas are currently being planned just downstream of Manantali Dam. Lessons from Senegal and Mauritania should be used to avoid similar health problems in these new areas.

THE PRODUCTION SYSTEM

The traditional socio-economic system in the valley comprises fishing, livestock production, and agriculture. The three sectors are interdependent because of the roles assigned to different socio-economic groups in society, the use of the physical environment and resources, and the organization of different socio-economic activities at different times of year. Traditionally, and up until the construction of the dams, the annual flood was the critical variable in the three components of the production system in the valley. The annual flood was a determining factor not only of the socio-economic system in the valley but also of the system of social organization (Schmitz, 1986). Traditionally, life in the valley was organized around the geographical depressions where flooding occurred every year in September, and wherein there was an annual rotation of the three economic groups and activities. Our objective was to analyze the effect of the construction of the dams on all three components of the production system and in turn on household food availability. In the Bafing River Valley in Mali, three other components of the production system include hunting, gathering of wild fruits, and producing traditional handicrafts.

The program for development of the river basin defined by the OMVS and the three member countries clearly emphasizes the agricultural sector. However, from a systems perspective, it is inevitable that changes in the agricultural sector will trigger changes in the other two sectors.

Fishing

Fishing has been an important activity in the SRV for centuries. Fishing constitutes a primary economic activity and an important source of protein in the local diet. As a result of the drought of the early 1970s, the population of both fish and fisherman in the valley had already significantly decreased. Before dam construction, studies conducted in the valley downstream from Manantali predicted that the population of salt and fresh water fish would further decrease once the dam was operational (Fleming et al., 1977). Early studies also concluded that behind Manantali Dam, annual fish production would initially greatly increase to 4,000 metric tons per year and later stabilize at around 3,000 metric tons annually. Based on these predictions, the OMVS envisioned a complementary strategy to support the fishing sector.

Interviews conducted with community members and agricultural extension agents in Mauritania and Senegal showed a general consensus that fish production in the river has significantly decreased since the dams have been operational. This opinion is supported by a 1994 ORSTOM/CRODT study which concludes that the dams have generally had a detrimental effect on fish production both in the valley and in the upper part of the Delta (Albaret, 1994). This is due to several factors. The major negative effect of the dams is due to the reduction of the annual flood and with it the disappearance of the floodplains where both fresh and salt water fish traditionally spawned each year. In addition, the floodplains were important feeding grounds for fish. The Diama Dam interrupts the traditional annual breeding cycle by preventing the fish from swimming upstream to spawn (**Figure 22**). The forceful releases of water from the dam, which can kill large numbers of fish, have also contributed to the decrease in salt water fish downstream from Diama Dam. All of these factors have contributed to the overall decrease in the fish population upstream as well as downstream from Diama Dam (Albaret, 1994).

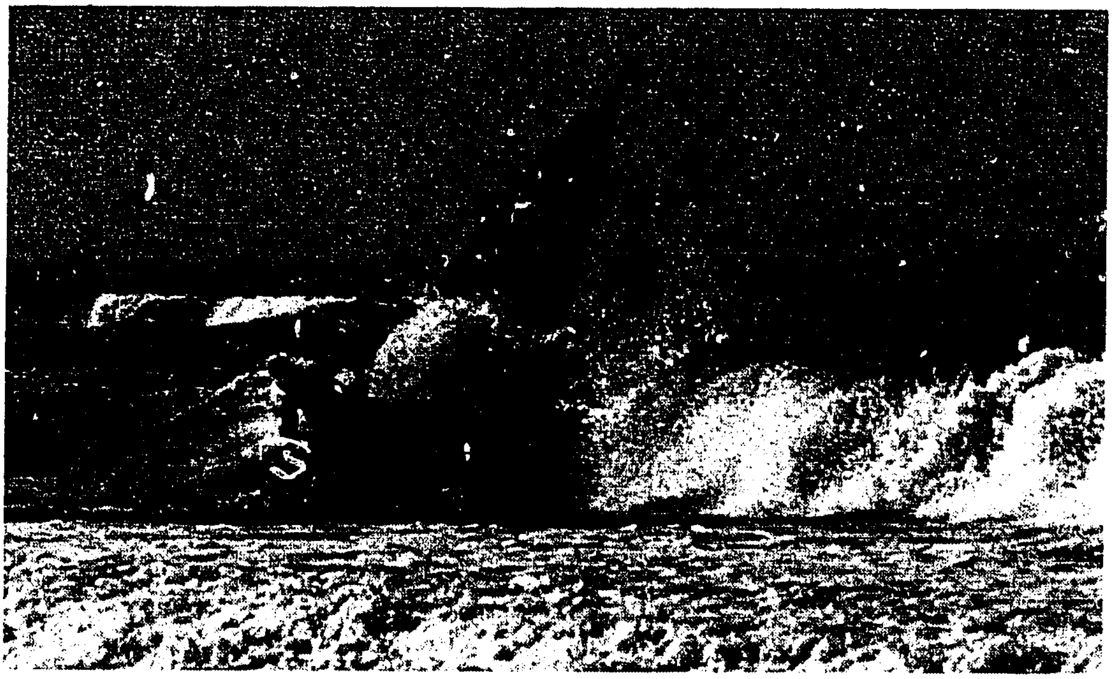
Following the filling of the reservoir, the fish population behind the dam initially increased considerably. However, since 1991 the annual catch has sharply fallen off (from 420 tons in 1991 to 285 tons in 1993). The population of the fishing villages on the lake was greatest in 1993, but now it is only 900 people (Limnology Laboratory, Manantali, 1994). The decreased catch is partly due to less effective techniques and equipment used by the fishermen, who are accustomed to river, and not deep-lake, fishing.

In the OMVS program, both before and since the construction of the dams, fishing was never identified as a priority. To date, the complementary strategy to promote fishing, initially envisioned by the OMVS, has not been implemented.

The inhabitants of the river valley in Senegal and Mauritania maintain that fish consumption has decreased since 1988 and that the fish presently consumed are almost exclusively salt water species trucked in from the Senegalese and Mauritanian coasts. However, specific data on dietary changes in the valley are limited and it is, therefore, impossible to formulate precise conclusions about changes in fish consumption.

Figure 22: Fishing along the coast of Senegal in Atlantic Ocean. A major coastal fishing industry existed near the mouth of the Senegal River prior to construction of the Diama Dam.

Figure 22: La pêche le long du littoral de l'Atlantique au Sénégal. Il existait une importante industrie de pêcheries près de l'embouchure du Sénégal avant la construction du barrage de Diama.



Senegal postcard photos: Maurice ASCANI

Livestock Production

Most inhabitants of the river valley traditionally have been involved in both agriculture and livestock production, specifically of cattle, goats, and sheep. Certain ethnic groups, namely the Peuls and Maures, are professional herders and are the most important cattle raisers. In addition, most Toucouleur, Wolof, and Soninke households have some animals that not only constitute a nutritional resource, but also primarily serve as a "savings account" to be used for family celebrations and for various household emergencies, such as illness.

During the years of drought in the Sahel (1970s), the number of animals decreased substantially and today the size of the herds is still smaller than what it was before the drought. For the past 30 years, rainfall in the river valley has consistently decreased. Given the importance of these environmental factors, it is impossible to isolate the effect of the construction of the dams on the evolution in herd size.

Studies conducted before the construction of the dams predicted that the disappearance of the annual flood and the expansion of irrigated areas would lead to a significant decrease in the amount of pasture land available for animals. To offset this problem, the OMVS proposed that 15 percent of the irrigated land be set aside for fodder production.

In the OMVS studies, it was also initially projected that in the Delta area, soil salinity would decrease because of the irrigation, and that throughout the valley, soil moisture content would increase and contribute to improvements in the quality of fodder grown. It was also anticipated that the crop residue from cereal production would constitute a supplemental source of nutrition for animals. An increase in animal illnesses was expected in irrigated areas because of increased soil moisture and increased presence of microbes and parasites in the soil (Heming et al., 1977). In spite of these constraining factors, the size of animal herds was predicted to generally increase following dam construction.

In community interviews in Mauritania and Senegal, interviewees' opinions vary from one area to another concerning the trends in herd size since 1988. The variance in their responses probably reflects that the factors which either hinder or favor animal-raising vary considerably from one area of the valley to another, and from one time of year to another. In certain places, interviewees stated that herd sizes have diminished because of the shortage of pasture land owing to the disappearance of the annual flood; the transformation of land close to the river into irrigated perimeters; the decrease in rainfall in the areas further away from the river; and the fact that certain areas which were formerly pasture lands are now flooded all year. Conversely, interviewees state that herd size is gradually decreasing in other areas because, during part of the year, many animals are taken out of the valley to other pasture areas (**Figure 23**).

As anticipated, since the two dams became functional, there has been a significant decline in the ~~total amount of pasture land in the valley (Santoir, 1994). It is important to point out, however,~~ that changes in available grazing land vary considerably from one place to another. Confronted with the problem of decreased pasture land, Peul animal herders have developed strategies that involve taking their herds outside of the river valley in the search for

Figure 23: Cattle herd in Bakel, October 1988. Cattle were the major component of herds maintained along Senegal River prior to construction of the OMVS dams.

Figure 23: Troupeaux de bovins à Bakel, octobre 1988. Les bovins constituaient la majeure partie des troupeaux gardés le long du fleuve Sénégal avant la construction des barrages OMVS.

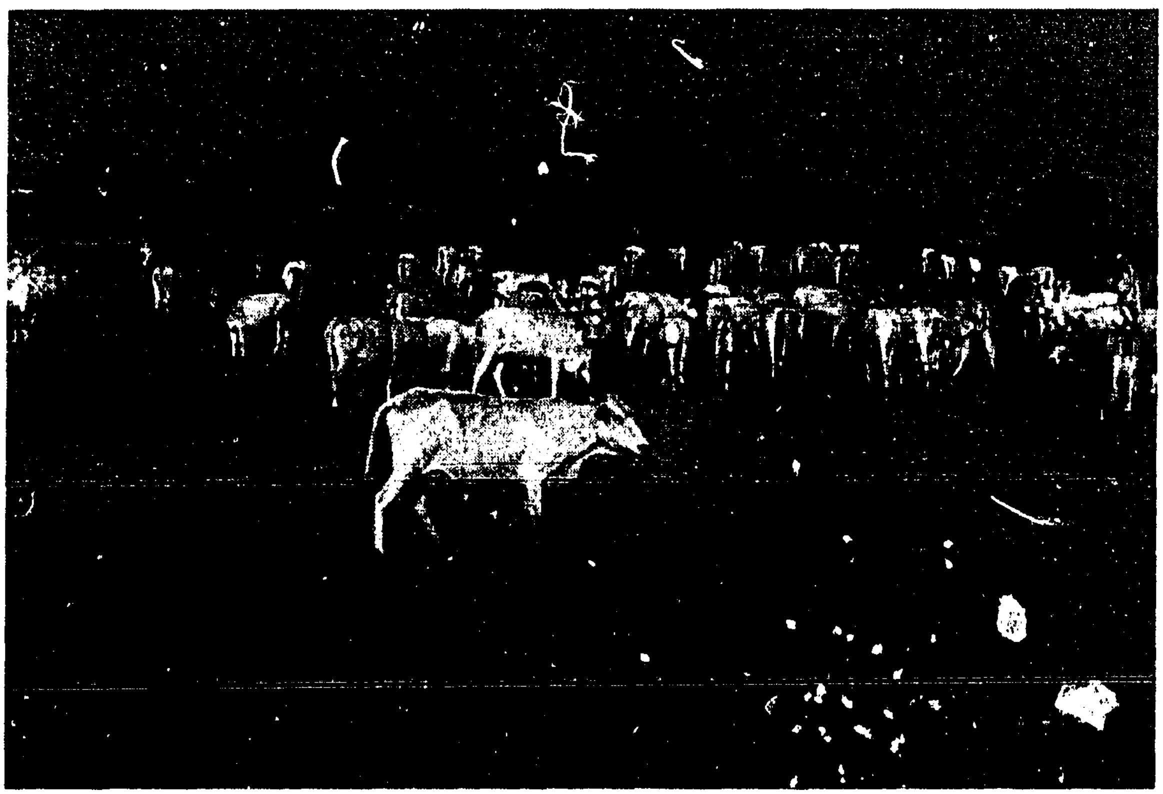


photo: Jobin

alternative pasture land; increasing the proportion of small animals relative to larger ones; and reorienting certain family members away from animal raising to sedentary agriculture (Santoir, 1994).

An additional problem that pastoralists have encountered is that in many cases when the irrigated areas were excavated no corridors were left to allow the animals to reach the river. Sometimes, animals have no alternative but to walk through irrigated fields, thus damaging crops or dikes. This has become a source of conflict between farmers and pastoralists in many places (Santoir, 1994).

Irrigation canals are now used to satisfy the drinking and bathing needs of the animals. Frequent use of irrigation canal water by animals presents two problems. First, the presence of animals in the canals contributes to the pollution of the canal water, which farmers often use for bathing and drinking. Second, the presence of fertilizer and pesticide residues in the canal water constitutes a potential health hazard for the animals. Community interviewees maintained that since the dams have been in operation, there has been more illness and death among their animals. They associate this with the pollution of the canal water.

In Mali, in the case of the resettled villages, the problems related to animals are similar to those found in Mauritania and Senegal. In plotting the locations for the resettled villages downstream from the dam, no consideration was given to the needs of animals. As such, neither corridors nor water points for animals were planned for. In general, villages are quite close together and, at the present time, grazing land is extremely limited (Semega et al., 1994).

It is difficult to formulate definitive conclusions about the effect the dams have had on livestock production because baseline and evaluation data do not exist on the amount of grazing land, animal health, the type of animals and size of family herds, family income from livestock production, and family consumption of meat and secondary animal products.

Nevertheless, the construction of the dams and the development of irrigated agricultural areas has not been beneficial for livestock production as was originally anticipated. Available information suggests that, as expected, the dams and irrigated areas have contributed to a decrease in grazing areas and to an increase in animal illness. In addition, the irrigated perimeters in many areas have contributed to a deterioration in relations between pastoralists and farmers. The supplemental programs that the OMVS had planned to ensure the production of sufficient animal fodder have not been realized. As predicted, the cereal crop residues are available for animal consumption only at certain times of year.

Even though grazing land in the valley has decreased since the dams became operational, the animal herds are presently increasing in size following their devastation during the droughts of the 1970s and 1980s. The increase is due to the creative strategies adopted by pastoralists, which primarily involve taking their animals outside of the valley at certain times of year (Direction de l'Elevage/Dakar, 1993; Santoir, 1994).

Agriculture and the OMVS

The health and nutritional status of the Senegal River Valley inhabitants is indirectly related to household agricultural production. The relationship is indirect because households do not consume all of the food they produce. In addition, many households receive substantial resources from household members who have migrated outside the valley (Minvielle, 1985).

A study conducted for the OMVS in 1977, before the construction of the dams, predicted that expanded development of irrigated agriculture, made possible through control of the water level in the Senegal River, would ensure several advantages to the three member countries as well as to the inhabitants of the river valley. According to this study, the advantages would include increased employment opportunities in agriculture and related fields, improvements in the socio-economic status of farmers in the river valley, and both qualitative and quantitative improvements in national food security.

The initial goal of the OMVS was to develop 375,000 hectares of irrigated land in the three countries (240,000 in Senegal, 126,000 in Mauritania, and 9,000 in Mali). To achieve this goal, the OMVS strategy involves a radical change in the agricultural production system in the valley from the traditional farming system based largely on flood recession and rain-fed agriculture to an intensive farming system based upon irrigation. The agricultural sector policies formulated both by Mauritania and Senegal clearly give preference to rice production over other crops.

Another key element of the strategies for irrigated agriculture adopted by Senegal and Mauritania is the double cropping of rice, i.e., 200 percent annual cultivation of irrigated plots. This is a very significant element insofar as it was the basis for the initial economic analyses of return on investment for the multimillion dollar OMVS program.

Traditionally, agricultural production in the valley consisted of three components:

- Rain-fed agriculture from July to October in the plains, or *djeri*, away from the edge of the river. Djeri crops were primarily millet but also included cowpeas and squash.

- Flood recession agriculture from November to February in the *oualo*. Oualo crops consisted mainly of sorghum, corn, and cowpeas.

- Dry season crops on the slopes of the river, or *falo*, area from March to June, such as cabbage and eggplant.

With decreased rainfall in the river valley, the importance of djeri crops has diminished, particularly in the Delta and Middle Valley. Before the construction of the dams, farmers were primarily involved in flood recession agriculture. It is important to point out that the cost of traditional flood recession and rain-fed agriculture is relatively low in terms of labor and capital requirement, as compared with irrigated agriculture. A number of studies have shown that the majority of the capital costs associated with irrigated agriculture in the valley come from remittances from family members who have migrated outside the valley (Diemer, 1987; Niasse, 1990). This clearly suggests that intravalley profits from irrigated agriculture are not sufficient to sustain irrigated agriculture.

In the OMVS strategy to replace the traditional agricultural production system with one based on intensive agriculture, a transition period of 10 years was envisioned. During this period, OMVS planned to release an annual artificial flood from Manantali Dam to allow farmers to continue to do some flood recession agriculture, in anticipation of the expansion of the irrigated areas and access to them for all farmers.

Since 1988, when the two dams became functional, agricultural activities in the valley have consisted primarily of irrigated rice production. For example, in the rainy season in 1993, in Senegal 83 percent of the irrigated areas were used for rice production while in Mauritania 86 percent of irrigated land was used for rice production (**Figure 24**). In both countries, the remaining land was used to grow corn, sorghum, tomatoes, and other vegetables (SAED, 1994; SONADER, 1994).

As a consequence of the policies of the OMVS and the national policies of Senegal and Mauritania that aim to transform the agricultural sector, Senegalese and Mauritanian farmers are currently confronted with two major problems related to the disappearance of the annual flood and a multitude of problems associated with the financing, technical aspects, and productivity of irrigated agriculture, specifically of rice farming.

Since 1988, the OMVS has experimented with releasing water from Manantali to create an artificial flood. Unfortunately, since the dams went into operation, 1988 was the only year in which the flooding was sufficient to allow farmers to harvest a normal crop (Figure 17 and **Figure 25**). Problems associated with the artificial flood relate to its inadequacy both in terms of the duration and volume of water released. Before the construction of the dams, it was estimated that 30 days of water releases would be required from Manantali to ensure a flood that would be adequate for cultivation. Discussions with the engineers at Manantali reveal that in their planning for the flood, each year only five days of water are released. In addition to the insufficiency of the water released, there are also problems related to the fact that farmers in the valley are not informed ahead of time when Manantali will be releasing the water. In conclusion, with the disappearance of the annual flood has come the disappearance of flood recession crops, which were the basis of the traditional agricultural and nutritional systems.

All of the Senegalese and Mauritanian farmers interviewed deplore the fact that because of the dams, they can no longer grow the traditional flood recession crops on the banks of the river. In general, farmers are now mainly involved in irrigated agriculture. In areas of the Upper Valley where annual rains are still adequate, farmers are less involved in irrigated agriculture and they continue to farm in the rain-fed djeri.

The second category of problems encountered by both Senegalese and Mauritanian farmers related to irrigated agriculture and specifically to rice production. A variety of serious problems include the availability of land, agricultural credit, development of the irrigated

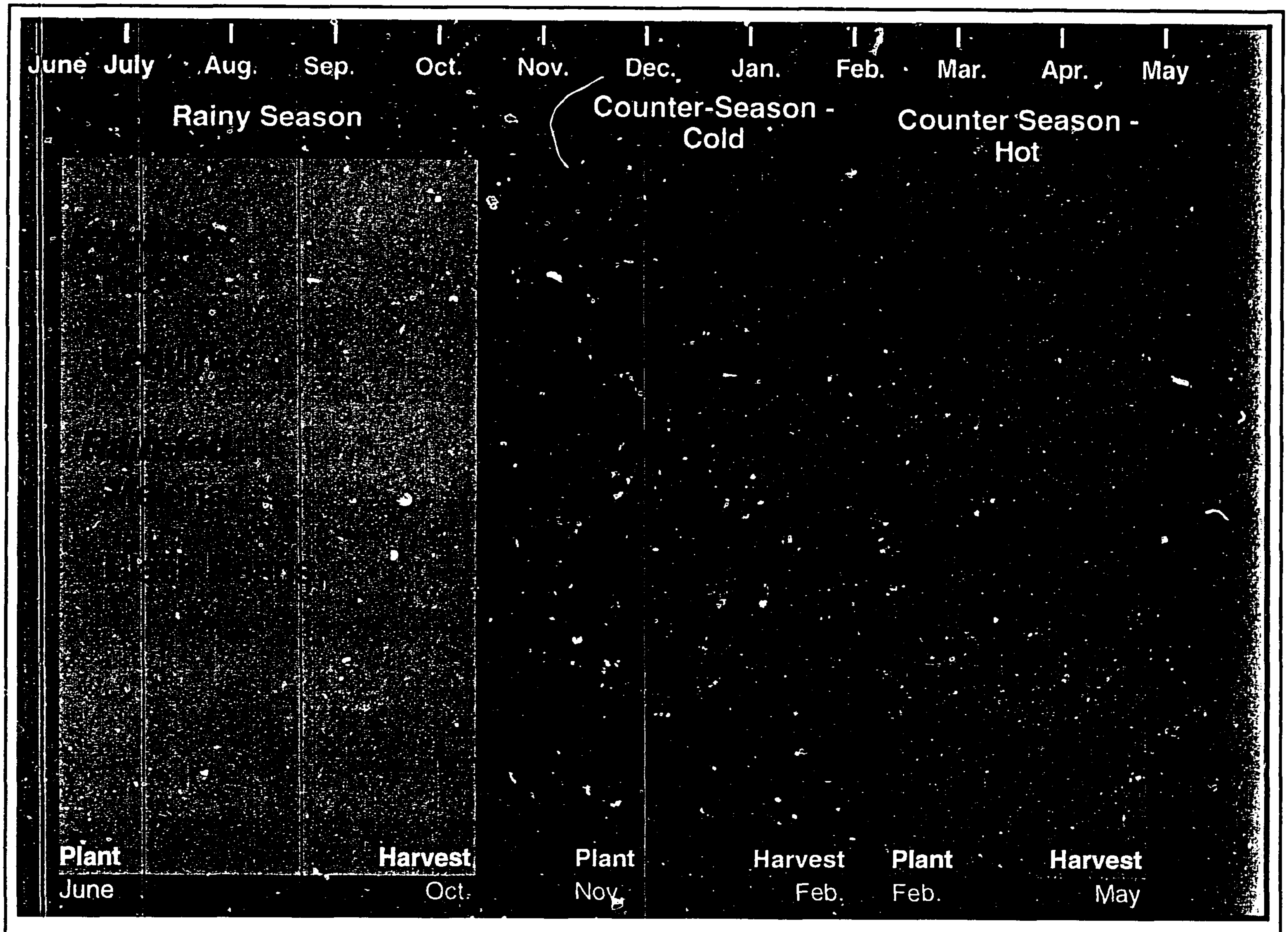


Figure 24: **Typical Three-Season Agricultural Calendar for Lower Valley of Senegal River Basin (SONADER, 1994)**

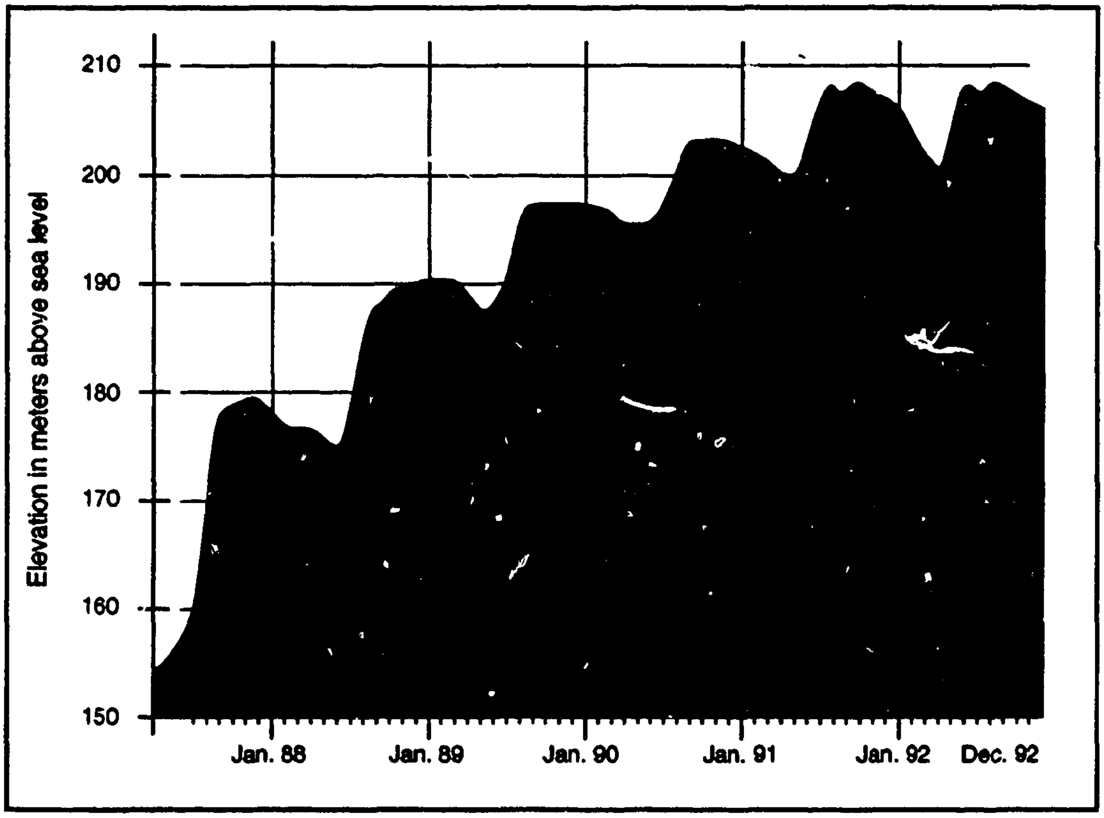


Figure 25: Water Level during Filling of Lake Manantali

plots, increasing soil salinity and infertility, availability and cost of agricultural inputs, delays in the start-up of the agricultural season, crop pests, rice marketing, rice yields and revenue, and progressive accumulation of debts by farmers. Each of these problems is described below.

Availability of land. Many farmers state that the irrigated plots to which they have access are too small. Originally, 0.5 hectare plots per family member were distributed. The increase in population, and the fact that for political or cultural reasons not all farmers were allotted land at the outset, contributes to the problem of land availability.

Agricultural credit. A constraining factor cited by most interviewed farmers relates to the slowness of the administrative procedures and high interest rates on agricultural credit (17.5 percent in 1994). Often, credit is approved after the agricultural season has already started. Late planting usually means lower yields.

Excavation and rehabilitation of irrigated plots. The initial costs of excavating one hectare of irrigated land are around one million CFA. After two to three years of use, plots must be mechanically rehabilitated with the cost depending on the extent of the rehabilitation.

Increasing soil salinity and infertility. In many areas, the inappropriate management of irrigated plots has caused the progressive increase in soil salinity. Increased salinity is a particularly severe problem in the Delta where the combination of high soil moisture and a very high water table (approximately one meter below the surface) contribute to the capillary action that brings salt to the surface. Over time, most farmers experience decreased soil fertility, which is also due to inadequate soil management (Faye, 1994).

Availability and cost of agricultural inputs. Compared to the costs of rainfall and flood recession agriculture, production costs associated with irrigated agriculture are high. On both banks of the river, farmers experience problems related to the cost and delays associated with the required inputs. For example, in 1993 the average production costs per hectare amounted to 381,150 CFA. On the basis of the price paid to the farmer per kilo of rice (85 CFA), a farmer needed to harvest 4.5 tons of rice per hectare just to cover expenses. Agronomists interviewed state that actual average yields are probably between 1.5 and 3 tons per hectare (Faye, 1994). Given the high production costs, even with a yield of 4.5 tons per hectare (average yield estimated by SONADER and SAED for 1993), a farmer has almost no return on investment. Although it was initially conjectured that irrigated agriculture would slow migration out of the valley, in some cases the poor return on investment has accelerated the exodus (Niasse, 1990).

Delays in start-up of the agricultural season. Decreases in yields are often related to delays at the outset of the season because of delays in the approval of credit, the unavailability of inputs such as seed and fertilizer, and delays in the mechanized preparation of the plots.

Crop pests. Attacks from birds, rats, crickets, and other pests also significantly contribute to decreased yields. In some instances, birds have destroyed more than 50 percent of a rice crop. The farmers' home-made strategies for dealing with such crop pests are not very effective. The decimation of a crop by such pests can explain a farmer's inability to reimburse the bank for a loan.

Marketing of rice. For many years, the governmental organizations in Se[illegible]gal (SAED) and in Mauritania (SONADER) facilitated the marketing of rice, but they are [illegible] [illegible]ger involved in this activity. Farmers often have problems transporting their harvest from the field to the market and selling their rice at a reasonable price at harvest when the market is glutted.

Poor rice yields. In Senegal, between the 1991-1992 and 1992-1993 agricultural seasons, the percentage of irrigated area actually farmed decreased. (In 1992-1993, only 59 percent of the irrigated area was under cultivation.) The total amount of irrigated farmland decreased from 40,287 hectares in 1991-1992 to 38,850 in 1992-1993. At the same time, rice yields fell from 5.18 to 4.49 tons per hectare (SAED, 1994). Furthermore, the SAED evaluation department acknowledges that all of these figures overestimate rice yields because of limitations inherent in their data collection methodology. As stated above, several agronomists and agricultural economists interviewed during this study stated that average yields are probably between 1.5 and [illegible] tons per hectare. It is generally estimated that irrigated rice production is profitable only when yields exceed 5 tons per hectare.

In Mauritania since 1992, irrigated areas have rapidly increased (from 4,584 hectares to 7,276 hectares in 1993) because of investments by large landowners. On the other hand, areas farmed by peasant farmers have decreased because of the high costs of inputs required for irrigated agriculture. Rice yields have decreased the past few years. In 1993, the average yield was down to 4.67 tons per hectare (SONADER, 1994).

Progressive accumulation of debts by farmers. According to both SAED and SONADER technicians, at the end of the 1993-1994 season, a majority of farmers on both sides of the river were in debt. SAED and SONADER staff believe that this trend will continue given the problems confronted by farmers and the withdrawal of government support in both countries for rice production.

As a result of the combined effect of the numerous problems confronted by most farmers involved in irrigated agriculture, the majority of farmers on both banks of the river are discouraged and in debt. In most cases, farmers' problems are related to the poor yields and consequently limited profits that accrue from rice production.

Agriculture in Senegal and Mauritania

The construction of the dams and stabilization of the water level in the Senegal River have produced dramatic changes in the agricultural system in the valley. Efforts to transform the traditional agricultural system based primarily on flood recession agriculture, to one based on intensive agriculture where rice is prioritized, are consistent with the objectives of the OMVS and of Mauritania and Senegal. However, these changes do not reflect the priorities of the valley inhabitants.

According to peasant farmers, agricultural extension agents, and agricultural researchers, irrigated cultivation of rice is expensive as well as complex in terms of inputs, is very demanding in terms of labor requirements, and involves numerous risks. All of these factors can contribute to decreased production and profits. In community-level interviews in both countries, farmers often state, "The advantage of the dams is that we now have water all year round. The disadvantage is the rice, which has brought us too many problems." Many farmers insisted that they would abandon rice production if they had an alternative, but to stop growing rice could mean the loss of their land. For that reason, they will do everything possible to continue to farm even if it is not always profitable. Furthermore, farmers deplore the fact that the annual flood has disappeared and with it the traditional flood recession crops.

The problems associated with the transformation of the agricultural system in the valley help explain that for most peasant farmers both food crop production and earnings that can be used to purchase other foodstuffs are relatively limited. The information collected in this study suggests that for most Senegalese and Mauritanian farmers in the valley, the disadvantages of rice production presently outweigh the advantages. Available information suggests that, in most cases, the dams and irrigated agriculture have not led to the anticipated improvements in the socio-economic status of the farmers in the valley.

Agriculture in Resettled Villages in Mali

In the Bafing Valley, both before and since the construction of Manantali Dam, agriculture constitutes the villagers' major economic activity. However, other activities include fishing, animal-raising, hunting, gathering of wild fruits, and the production of traditional craft articles. Before construction of the dams, the villages in the area later flooded by Lake Manantali had ample farm land. They routinely cultivated a plot for two years and let that plot lie fallow for several years while they farmed elsewhere. Then they came back to farm the original plot.

Since the resettlement of the 26 villages from upstream to downstream of Manantali Dam, the main problem encountered by villagers relates to their access to good farming land. The size of the plots they were allocated are relatively small, compared with the size of their pre-dam plots. However, soil fertility in the resettled sites is increasingly a problem largely because villagers are required to farm the same plots every year. They are unable to leave part of their land lie fallow. When family plots were initially distributed in 1986, each adult was allocated .08 hectares. The plots were small, and since 1986 the population has continued to grow at a fast pace.

In addition to the limited size of plots and to decreasing soil fertility, other factors that have contributed to decreased yields include limited availability of fertilizers, lack of necessary farm implements, discontinuation of the agricultural credit scheme, crop loss owing to crop pests, and the proliferation of weeds. The dramatic decrease in yields between 1988-1989 to 1993-1994 is illustrated by the decline in peanut yields, from 1,107 kilos/hectare to 900 kilos/hectare; and in millet yields, from 934 kilos/hectare to 700 kilos/hectare. Lower yields contribute to decreased household revenues and to decreased resources for household food.

Before resettlement, another important source of family income and food was gardening, which was mainly the responsibility of women. Women grew eggplant, onions, tomatoes, gumbo, green peppers, peas, cotton, and tobacco. Since resettlement, the women's gardening activities have significantly decreased because of the limited availability of land and water, as well as poor soil fertility. Most women were involved in gathering wild fruits and plants for nutritional, medicinal, and handicraft purposes. In the resettlement area, the population is reasonably dense and the forest is much more sparse. At present, only about 50 percent of the women are still involved in gathering activities in the forest. With decreased access to forest areas, hunting has also become less important and as a result the consumption of wild game has decreased.

Women and Rice Production

For many years, economic hardship has encouraged men to migrate from the region. In Senegal, it has been estimated that between 45 to 65 percent of the men leave the valley to work abroad or elsewhere in the country (Minvielle, 1985). Women play an important role in irrigated rice production in the valley. The importance of their role is accentuated by the out-migration of men from the valley and by the fact that rice farming is labor intensive and, therefore, requires the participation of all available family members.

Compared with traditional flood recession agriculture, rice production requires considerably more labor inputs (Diemer and Van der Laan, 1987). Traditionally, Haalpuular (Toucouleur and Peul) women played only a limited role in agriculture. With the expansion of irrigated farming, their agricultural responsibilities have increased.

At all times of the year, women's overall energy output, combining their domestic and agricultural activities, is greater than that of men (Benefice, 1994). At the same time at the household level, their nutritional intake generally appears to be less than that of men. This suggests that women are generally at greater nutritional risk than are male family members.

In the Senegal River Valley, the rainy season is the primary rice growing period. As elsewhere in West Africa, the rainy season, often referred to as the "hungry season," is the time of year when there is more work and less to eat. The health risks associated with the rainy season are reflected in the fact that at this time of year there is more child and maternal morbidity and more low birth weight babies (Sadio, 1993). During the rainy season, pregnant and breastfeeding women are particularly at risk. Yet studies have shown that in the Senegal River Valley, such women work as much as non-pregnant and non-breastfeeding women (Benefice, 1994).

In-depth community-level interviews, indicate that children's nutritional situation may be negatively affected by the women's heavy workload during the rainy season. At this time of year, women spend more time away from home and have less time and fewer resources to take care of their children.

HOUSEHOLD FOOD AVAILABILITY

From the perspective of the OMVS and the member countries, the construction of the dams and the expansion of irrigated agriculture were to contribute to improved household food availability for the inhabitants of the river basin. In the case of the resettled villages in Mali, the objective was to ensure that in the resettlement sites inhabitants had the same standard of living as that which they had before resettlement. Our primary objective was to identify changes in the diet of families involved in irrigated agriculture in the basin since the dams became operational.

Senegal and Mauritania

It is important to understand the fact that in the Senegal River Valley, a direct relationship does not exist between household agricultural production and household food availability. A part of the harvest is typically sold to purchase other foodstuffs and household items and to reimburse debts incurred within the village and at the bank. But in a majority of cases, a significant percentage of the food consumed by the family is purchased with resources provided by family members who have migrated outside the valley. In the case of Toucouleur households, it is estimated that approximately 50 percent of food expenditures are covered by resources coming from outside the valley (Benefice and Simondon, 1993). In Wolof households, outside contributions can constitute as much as 65 percent of expenditures, while in Soninke households, remittances account for about 53 percent of household food budgets (Minvielle, 1985). Remittances from migrants for household food expenditures appear to be greater on the Senegalese side of the river than on the Mauritanian side.

Comprehensive and reliable data on the household food availability situation before and after dam construction, which would allow a systematic comparison, does not exist. Nevertheless, the available qualitative and quantitative information does enable us to form general conclusions about the trends over the past few years.

In general, the quality of the diet appears to have deteriorated. In the context of this study, interviews in Senegal and in Mauritania with farmers and agricultural extension agents suggest that family diet has deteriorated since the construction of the dams. Present agricultural production consists mainly of rice. For rice producing families, rice is the predominant food in the diet, and it is usually eaten two to three times a day.

Data collected near Podor in Senegal shows that daily rice consumption more than doubled between 1983 and 1991, from 188 grams to 388 grams per day (Benefice and Simondon, 1993). During this same period, there was a dramatic decrease in the daily consumption of traditionally eaten cereals and legumes, namely, millet and sorghum, from 164 grams to 16 grams per day, corn from 20 grams to 6 grams per day, and cowpeas from 26 grams to 19 grams per day. Even when families purchase food, they are often unable to find millet, sorghum, or cowpeas in the market. Compared to millet and sorghum, rice is less nutritious in terms of protein content. Since the construction of the dams, fish, meat, and dairy product consumption also appears to have decreased. Compared to the pre-dam period when the diet of families contained foods of greater variety and of greater nutritional value, rice production has significantly modified household diet and contributed to a decrease in its overall quality.

A second factor in household food availability relates to the constraints associated with irrigated rice production. Rice yields are often poor and, hence, profits limited for the purchase of other foodstuffs. In most cases, families are required to buy food between four and six months per year, starting in June. Rice and other food items are usually purchased in village shops where a 100 percent interest rate is frequently applied, reimbursable after the harvest. Poor rice yields explain the fact that the majority of Senegalese and Mauritanian farmers have either progressively gone into debt or experience continuously low profit margins.

The expectation was that the availability of year-round water and the adoption of an intensive mode of agricultural production would ensure food self-sufficiency for valley inhabitants. The available data suggest that self-sufficiency is far from being realized. In qualitative terms, for most farming families their diet has become progressively poorer because of the prevalence of rice in the diet and the decreased variety in foods consumed. In quantitative terms, household food production in many cases provides only about 50 percent of the resources necessary to cover household food requirements. For families who depend exclusively on their own resources to feed the family, it appears that household food availability is tenuous all year.

While these appear to be the trends in household food availability, it is not possible to formulate definitive conclusions in this regard given the fact that extensive data from various sites in the two countries, collected in both the pre- and post-dam periods, are not available on either household food availability or on the origin of household food resources.

Resettled Villages in Mali

In the case of the resettled villages in the Bafing Valley, data on household food availability before and after resettlement are not available. Resettled villagers, maintain in interviews that the food situation is more precarious now than it was before resettlement. They attribute the degradation in their diet to several problems that they have encountered since resettlement: limited availability of farm land; soil infertility; low yields per hectare and per household; and decreased consumption of fish, meat, wild game, and wild fruits. It is difficult to confirm the reliability of this information. Their statements may be clouded by resentment over being required to move their villages. They also tend to identify numerous difficulties and few advantages associated with their present situation.

NUTRITIONAL STATUS

The nutritional status of a population depends not only on food consumption but also on other factors, namely sanitation conditions, infections, and calorie expenditure. In addition, nutritional status often varies from one time of year to another.

After the droughts and famines in the 1970s and 1980s, the creation of the OMVS brought with it the expectation that the dams would contribute to improvements in the nutritional status of the inhabitants. Unfortunately, comprehensive data that would allow us to precisely describe the changes in nutritional status before and after dam construction do not exist. Nevertheless, using previously existing data and information collected during this study, we concluded that the nutritional situation in the SRV generally remains unsatisfactory, and at the present time high levels of malnutrition persist.

Senegal and Mauritania

Villagers interviewed in Mauritania and Senegal clearly state that their health has deteriorated in the past few years because of the deterioration in their diet. They are convinced that before the construction of the dams, when they produced traditional flood recession crops in the oualo, their diet was more varied and hence more healthy. They insist that it is because of their present diet, made up primarily of rice, that they are weaker and have more health problems than before. This information is qualitative and subjective in nature based on villagers' opinions about changes that they have observed. Psychologically, many of the villagers involved in rice farming are upset by the changes that have been imposed on their production system and dietary habits. Their state of mind may affect the reliability of their responses and their frustration may have incited them to give an exaggerated report of their food and nutritional situation.

In Senegal, several studies conducted since 1988 reveal high levels of malnutrition among river valley inhabitants. A 1990 study conducted by ORANA in the four administrative departments along the river showed very high levels of malnutrition in children 0-5 years of age (36 percent chronic malnutrition) and in women (25 percent chronic malnutrition). In another study conducted by UNICEF in 1991, 20 percent chronic malnutrition was found among children in Podor and Matam. Research conducted in the Podor area by ORSTOM in 1990 and 1991 reveal high levels of malnutrition among children (between 20 and 29 percent chronic malnutrition) and among adults (20 to 25 percent). In this same research, a comparison of nutritional status in 1983 and 1992 revealed that the levels of malnutrition were almost the same.

Data collected between 1990 and 1992 during the dry season, by Simondon and Benefice (1993), show a decrease in the prevalence of malnutrition in preschool children (22 percent stunting in 1990 and 16 percent in 1992; 11 percent wasting in 1990 and 5 percent in 1992). Similarly in adults, these studies showed a decrease in the prevalence of malnutrition to a greater extent in men (23 percent chronic energy deficiency in 1990 and 10 percent in 1992) and to a lesser extent in women (22 percent chronic energy deficiency in 1990 and 16 percent in 1992).

While the available studies suggest significant levels of malnutrition on the Senegalese side of the river, the prevalence of malnutrition is lower in the regions bordering the Senegal River than in some of the other regions of the country (UNICEF, 1991).

In the case of Mauritania, in a study conducted in 1986 in Trarza Region (Rosso), levels of chronic malnutrition were found to be 25 percent in children 0-5 years of age. In our study in 1994, anthropometric data collected on women and children in rice-producing villages close to Rosso reveal very high levels of chronic malnutrition (36 percent in children). The nutritional status of Mauritanian children on a national scale, however, is generally precarious. Malnutrition rates in children vary from 25 to 45 percent in Mauritania. In our study, we found only 4 percent malnutrition in women.

A comparison of nutritional data collected on both sides of the Senegal River suggest that the level of malnutrition in children is higher in Mauritania than in Senegal. For example, in terms of chronic malnutrition, our study in the Rosso area revealed a prevalence of 36 percent; whereas in Senegal in 1991 a prevalence of only 20 percent was found. In terms of nutritional wasting, in Mauritania in our study we found a prevalence of 11 percent; whereas in Senegal in 1991, a prevalence of 9 percent was calculated.

Resettled Villages in Mali

Interviews conducted in the resettled villages reveal that globally the type of food now eaten differs little from what was eaten before resettlement. As was the case before resettlement, the local diet consists primarily of grains; few fruits or vegetables are eaten. According to community interviewees, since resettlement the amount of fish, meat, and wild fruits in their diet has decreased.

According to studies conducted in 1986 before resettlement, and in 1989, two years after resettlement, it appears that the nutritional status of children improved. Since 1989 it appears to have deteriorated (Semega et al., 1994). For the first two years after resettlement, villagers regularly received food donations from the World Food Program. In 1986, the level of malnutrition in children 0-5 years of age was 34 percent (weight for age); whereas in 1989 it had decreased to 23 percent. In 1994, anthropometric data collected in resettled villages revealed a significant prevalence of malnutrition in children 0-3 years of age (36 percent low weight for age, 33 percent wasting, and 21 percent stunting) (Semega et al., 1994). Downstream of the dam, however, the levels of malnutrition in children in the resettled villages are generally less than in those villages.

In the 1986 and 1989 studies, women's nutritional status was not evaluated; in the 1994 study, 18 percent wasting was found in reproductive-age women. Owing to the absence of any baseline data, it is impossible to conclude how women's nutritional status has evolved since resettlement. The 18 percent malnutrition rate does suggest that there are significant problems related to women's nutritional status.

CONCLUSIONS

To precisely describe the changes in nutritional status, extensive baseline and evaluation data would be required which, unfortunately, do not exist. In the entire river valley, virtually the only longitudinal data collected are from an ORSTOM-supported research project conducted from 1990 to the present in the Podor area in Senegal (Benefice and Simondon, 1993). This study shows that the levels of malnutrition among children and adults are at present unacceptably high and that in comparison with the early 1980s the overall nutritional situation has improved very little.

In the absence of more comprehensive data, we cannot formulate definitive conclusions about changes that have come about in the nutritional status since the dams have been operational. Nevertheless, the available information does permit us to say that the nutritional status of the rice-growing population in the valley is unsatisfactory as demonstrated by the high levels of malnutrition that prevail. We can also conclude that the present agricultural production system based on irrigated crops, which prioritizes rice production, does not ensure either adequate nutritional resources nor household food self-sufficiency as initially expected.

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Chapter 8: Guinea Worm Disease, Onchocerciasis, and Rift Valley Fever

GUINEA WORM DISEASE

Introduction

Guinea worm disease is caused by a parasitic worm called *Dracunculus medinensis*. Infection with guinea worm is therefore also called "dracunculiasis." The disease is transmitted to humans when they drink water containing infected cyclops. Cyclops are tiny crustaceans (copepods), also called "water fleas," which feed on plankton and small water organisms. The cyclops are just visible (0.5-2 millimeters) and can be recognized by their jerky mode of swimming. They are usually found in stagnant bodies of fresh water such as wells and ponds. Cyclops can survive under dry conditions, from one rainy season to the next because they are drought resistant. The density of cyclops often becomes highest during the dry season when rivers, streams, and ponds form shallow pools. In arid areas, they may reach their highest densities during the rainy season. The eggs are easily dispersed to other places by animals or floods and can start new populations.

Guinea worm disease is rarely fatal but severely debilitating and affects two to three million people in poor agricultural communities in rural or peri-urban areas. A person's lower limbs are most commonly affected, but the worms (up to one meter long) can emerge from any part of the body. There are no drugs to treat the disease, but highly effective and simple measures to prevent the disease are available. Most endemic countries including Senegal, Mauritania, and Mali have now adopted a program to eradicate the guinea worm by taking simple, preventive measures, such as making the supply of drinking water safe.

Several countries have already made dramatic progress. Pakistan has almost eliminated the disease after three years of concentrated efforts; India has obtained a reduction of more than 95 percent in the number of cases since 1984; and Ghana and Nigeria have obtained a reduction of more than 80 percent in the number of cases after three years of intervention.

In Senegal and Mauritania, guinea worm disease occurs mainly in areas without proper water supply where pools in riverbeds in the dry season are used for collection of drinking water (**Figure 26**). In Senegal, the National Eradication Program started in 1991-1992. Control activities consist of free provision of filter material, health education, formation of village health workers and, perhaps in the future, the use of Abate (an insecticide that can be applied to water in pools to kill the cyclops but which is safe to humans and animals). Financial support is provided, among others, by UNICEF. In 1992, the total number of cases was 728. The situation in 1993 is shown in **Table 5**.

Figure 26: Contaminated drinking water at end of dry season. Nomads congregated around small pools in dry bed of Gorgol River during 1974 drought, creating conditions for the transmission of Guinea Worm.

Figure 26: Eau de boisson contaminée à la fin de la saison sèche. Des nomades se réunissent autour de petits points d'eau dans le lit à sec du fleuve Gorgol pendant la sécheresse de 1974, céant des conditions propices à la transmission de la draconculose.

photo: Jobin

Table 5. Endemicity of Guinea Worm Disease in Senegal, 1993

District	Number of Endemic Villages	With Sources of Potable Water	Without Potable Water	Other Villages	Number of Guinea Worm Cases in 1993
Bakel	85	11	64	10	185
Kedougou	40	0	40	0	283
Matam	40	5	32	3	162
Totals	165	16 (9%)	136	13	630

In 1993 in Mauritania, 511 endemic villages and 3,533 cases were detected; and in Mali 1,230 villages with 12,011 cases. Both countries have established an eradication program using the same approach as that in Senegal.

Observations

The only area we visited with guinea worm transmission was near Mbout. The area has higher rainfall (about 400 millimeters) than places visited to the west, downstream along the Senegal River. The area is covered with spread out shrubs and interspersed with beds of dried out creeks (in May). People were observed in the dry river beds near residual pools washing laundry, bathing, and collecting drinking water. According to interviews with some of the people, guinea worm disease was still a problem in the area, although a control program had already started. The hospital director in Kaedi claimed that the disease was mainly limited to areas far away from the Senegal River. People living close to the river collect (safe) drinking water from the river.

According to the officer in charge of the health center in Bamafele, near Lake Manantali in Mali, 7 out of 33 villages were endemic in 1991. Since then, a control program has been implemented successfully, and no more cases have been reported. Guinea worm disease reportedly becomes more common downstream toward Kayes.

Discussion

It seems unlikely that the construction of the dams has had a major effect on the incidence of guinea worm disease. However, the year round availability of flowing water in the Foum Gleita and other irrigation schemes, as well as in the Senegal River, may have reduced the risk of contracting the disease for people living close to the canals and river where they collect their drinking water. Donor-funded projects are under way in many areas to provide safe drinking water through the construction of pit wells. Moreover, guinea worm disease eradication programs seem to have made significant progress in all the three countries. Specific recommendations to the OMVS are therefore not needed.

ONCHOCERCIASIS (RIVER BLINDNESS)

Introduction

River blindness is caused by a parasitic filarial worm, *Onchocerca volvulus*. It is transmitted from person to person by infected *Simulium* blackflies. Transmission is most common near fast-flowing rivers or streams where the blackfly breeds and where it may attack humans in large numbers. Infection can cause severe itching of the skin, severe eye lesions, and blindness. The disease occurs throughout West, Central, and parts of East Africa. The most heavily infected areas are savanna regions in West Africa. Transmission also occurs in localized areas in Yemen and in Central and South America. The total number of infected persons in the world is estimated at almost 18 million, including 326,000 who have been blinded by the disease.

Prevention of infection with onchocerciasis is only possible by controlling the blackflies. A newly developed drug, ivermectin, has recently become available. The drug kills the larvae of the worms (microfilaria), but does not kill the adult worms. However, retreatment once a year with one tablet is sufficient to prevent blindness. It also prevents the microfilaria from reappearing. It is now being used on a large scale to treat infected people free of cost and to stop further development of the disease.

The Onchocerciasis Control Program

In West Africa, the Onchocerciasis Control Program (OCP) of the WHO, UNDP, World Bank, USAID, and countries of West Africa started in 1975. It attempts to reduce the blackfly population to a low level over a sufficiently long period (up to 20 years) to interrupt transmission of the parasite and to allow the adult worms, which can live in humans for up to 12 years, to die out completely. The program is based on large-scale aerial applications of insecticides and, in recent years, the distribution of the drug ivermectin. The application of insecticides into streams and rivers to destroy the larvae is the only practical method to control the blackfly vectors of onchocerciasis. Application of an insecticide to a selected breeding site usually also results in the killing of larvae in breeding sites located up to ten kilometers downstream because the insecticide is carried with the flow of the water.

One of the reasons for the large-scale applications, covering enormous distances and a large network of streams and watercourses, is the ability of the blackflies to fly with the wind over long distances of up to several hundred kilometers. Localized control of breeding sites would therefore not be sufficient because of the likelihood of reinvasion of blackflies from other areas.

In the 11 West African countries covered by the OCP, which include Mali and Senegal but not Mauritania, the control of onchocerciasis used to be based on a combination of blackfly control and the distribution of ivermectin. It is hoped that the distribution of ivermectin once a year to all people in areas at risk is sufficient to eliminate the disease. In all other endemic countries in Africa, Yemen, and Latin America, control is limited to the periodic distribution of ivermectin. Because of the high cost of the blackfly control operations and the availability of a cheap and effective drug, it is planned to terminate the large-scale spraying activities in the OCP area completely.

Blackflies (Figure 2) are quite small with a length of 1.5 to 4 millimeters. Biting occurs in the daytime and outdoors, especially along riverbanks. Normally they do not enter houses. They lay eggs in flowing, oxygen-rich, water such as streams, spillways of dams, fast-flowing rivers, and rapids. The larvae, which feed on small suspended particles, do not swim but remain attached to submerged vegetation, stones, and other substrates. Depending on the climate, the larval stage lasts from one week to several months.

Observations

There is no risk of blackfly breeding and transmission of onchocerciasis in the Lower and Middle Valleys of the Senegal River because of the absence of waterfalls, rapids, or fast-flowing water. The difference in altitude between St. Louis and Bakel is only 11 meters. Upstream, the first rapids are near Kayes, which is located on the edge of the area where blackflies do occur (**Figure 27b**). Upstream from Kayes rapids, blackflies are increasingly common. It is only because of the OCP activities that onchocerciasis is now under control in this area. The health services distribute ivermectin once a year free of charge to all inhabitants of (formerly) endemic areas. As long as this strategy is continued, it can be expected that the risk of infection with onchocerciasis will remain minimal.

Before the construction of the Manantali Dam prevalence rates in villages near the Bafing River were around 30 percent. Since the closure of the dam, blackfly breeding sites disappeared because of the filling of the lake, thus the disease disappeared from the lake area. In the villages downstream from the dam prevalence rates were quickly brought to very low levels because of the control activities by the OCP. However, it seems likely that the regulation of the river flow by the dam operators also contributed to the decline in blackfly densities and onchocerciasis transmission. The river flow is often cut abruptly for periods of 1 to 10 days, with cuts in discharge from 50 to 90 percent (**Figure 27a**). The resulting drops in water level strand the blackfly larvae attached to rocks and vegetation.

RIFT VALLEY FEVER

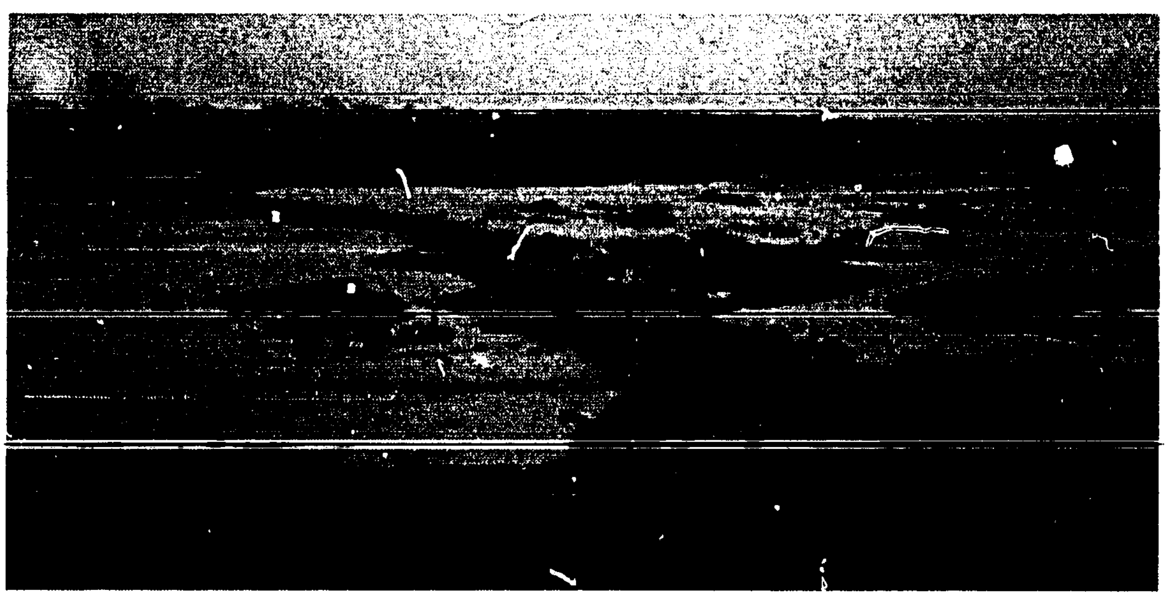
Introduction

Rift valley fever is caused by an arbovirus belonging to the genus *Phlebovirus* of the Bunyaviridae family. It is transmitted to man and animals by biting insects, such as mosquitos, sand flies, and midges, and possibly also by ticks. Infection is also possible through contact with blood and organs of slaughtered infected animals. It is mainly observed in animals in Africa south of the Sahara where it can cause heavy loss among domestic animals such as sheep. Mortality in adult animals is usually moderate, but abortion and stillbirth rates can be high. Epidemics occur in humans that generally cause relatively benign infections but which occasionally cause severe illness and death. An epidemic near Aswan in Egypt in 1977 caused 18,000 cases and about 600 deaths. The first epidemic recorded in

Figure 27: Blackflies breed in fast water. Steep reaches in the Senegal River create rapid flow near rocky outcrops, providing breeding sites for the blackflies which transmit River Blindness. Just below Manantali Dam *(a)* a discharge of about 100 cubic meters per second created ideal conditions for the blackflies. Further downstream at Kayes *(b)* this causeway area becomes a breeding site when flood flows cover it in late July or August.

Figure 27: Les mouches noires se multiplient dans les eaux rapides. Des plans trés inclinés dans le fleuve Sénégal expliquent le courant rapide près des rochers affleurants à la surface, créant des endroits où se multiplient les mouches noires, vecteurs de la cécité des rivières. Juste en-dessous du barrage de Manantali *(a)*, un debit d'environ 100 mètres cube par seconde crée des conditions idéales pour les mouches noires. Plus en aval près de Kayes *(b)* cette partie empierrée est propice à la multiplication des mouches noires lorsque les crues la recouvrent á la fin de juillet ou en août.

(a)



photos: Jobin *(b)*

West Africa took place in 1987 and caused almost 300 deaths in Rosso, Mauritania (Jouan et al., 1988).

It has been suggested that the epidemics in humans in Egypt and Mauritania were related to the filling of water reservoirs after the construction of dams at Aswan, Diama, and Foum Gleita (Jouan et al., 1989; Jobin, 1989). The Aswan lake reached its high-water line one to two months before the outbreak of the epidemic. Just above the high-water line were the encampments of people relocated from the flooded area. Mosquitos breeding around the fringe of the lake were therefore close to humans as well as domestic animals. Nomadic people with herds of sheep settled around the lake during the hot season. The mixture of mosquitos, non-immune (resettled) people, and sheep carrying the virus may have contributed to the epidemic.

A. Jouan (1989) who investigated the epidemic in Rosso immediately after the outbreak in 1987, reported that mosquitos were unusually abundant in 1987. This abundance was probably due to ecological changes caused by the filling of Diama Dam and the simultaneous introduction of irrigated rice fields along the Senegal River (**Figure 28**). The Senegal River reached its high-water line in August 1987, one month before the onset of the epidemic. In addition, rainfall had been higher than usual and was spread over a longer period. Higher than usual rates of abortions were observed in animals before the human epidemic.

During our visit, we tried to obtain more information about the epidemic in an effort to better understand the factors that caused the epidemic and may again cause an epidemic. It should be noted here that the Pasteur Institute in Dakar has obtained information about increased transmission of rift valley fever during 1993 in domestic animals and wild rodents (desert rats) along the Senegal River. Doctors and health workers have been alerted to the possibility of receiving patients with the symptoms of rift valley fever.

Methodology

Information was collected by surveying the area of Rosso for possible mosquito breeding sites; by discussions with health workers and inhabitants, including the relatives of some of the victims of the epidemic; and by collecting rainfall data from the meteorological station in Rosso.

Results and Discussion

In the absence of dikes in 1987, land near Rosso was probably flooded during the annual flood, providing abundant breeding sites for mosquitos. It is uncertain whether the flooding of land really was an essential factor enabling mosquito populations to reach high densities. The table below shows essentially that rainfall in 1987 also started quite early and was spread out over several months (**Table 6**). Being essentially a desert town, Rosso does not possess a drainage system for the disposal of waste or rain water. During the wet season, pools form everywhere in and around the town and mosquitos reportedly reach very high biting densities. The early start and long duration of the rainy season in 1987 may have provided better than average breeding conditions.

Figure 28: Site of Rift Valley Fever epidemic of 1987. Ferry boat crossing at Rosso in Trarza Region of Mauritania, one of the two sites of October 1987 epidemic of Rift Valley Fever.

Figure 28: Site de l'épidémie de [illegible] fièvre de la vallée Rift en 1987. Bac traversant à Ross[illegible]s la région de Trarza en Mauritanie, un des deux sites de l'épidémie de la fièvre de la vallée Rift qui a sévi en 1987.

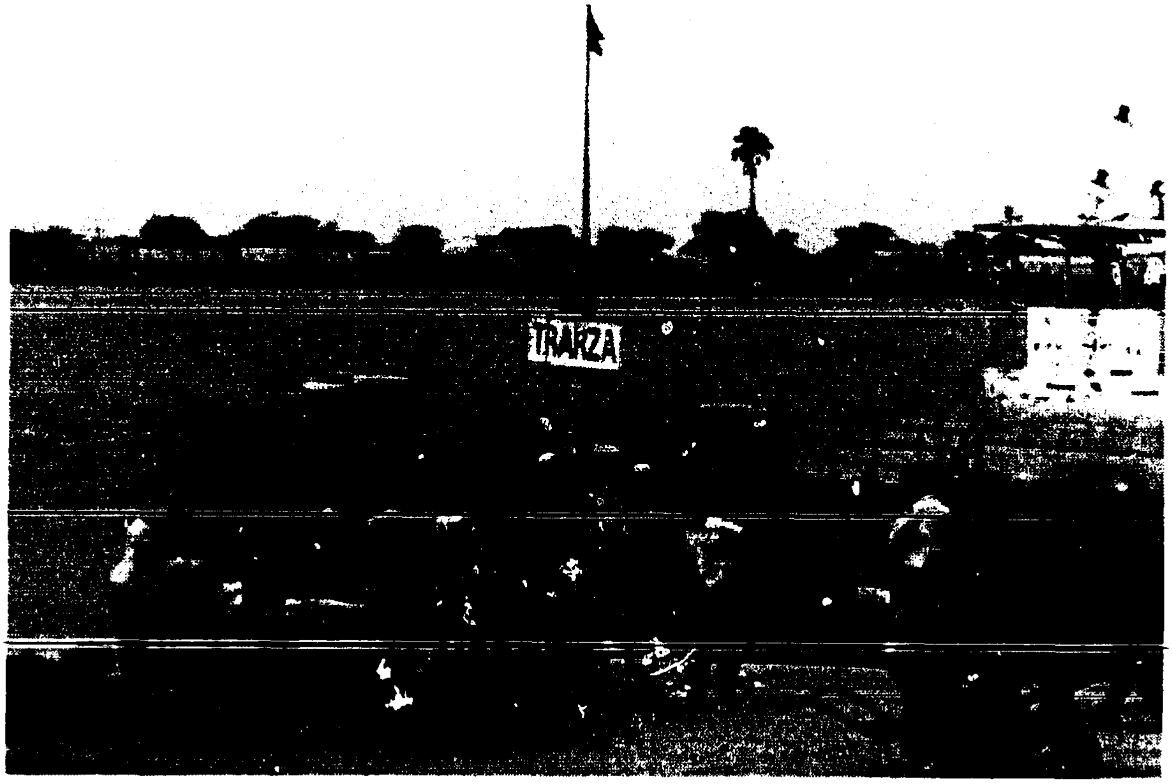


photo: Jobin

Table 6. Monthly Rainfall in Millimeters in Rosso, Mauritania for 1986, 1987, and 1993

Month	1986	1987	1993
January	0	0	0.8
February	2.4	0	0
March	0	0	0.8
April	0	0	0
May	0	0	0
June	0	9.4	0
July	11.0	23.5	20.4
August	126.9	51.5	121.1
September	191.2	102.0	45.0
October	0	11.0*	0
November	5.0	0	0
December	2.4	0	0
Totals	**338.9**	**197.4**	**188.1**

* First death reported from rift valley fever

Interviews with the director and other staff of the hospital did not produce any relevant information. No records have been kept about the casualties. A report issued by the Ministry of Health mentioned 349 cases of which 50 percent had only fever. The remaining cases suffered from haemorrhagic fever often resulting in death. The headmaster of a primary school remembered the epidemic and could name at least one of the victims. The father of an other victim, a 16-year-old girl who died November 14, 1987, remembered the epidemic and claimed that deaths were not restricted to one particular area but occurred throughout Rosso.

The virus could have been introduced with the large numbers of sheep and goats brought into Rosso during July and early August; the annual feast of Tabaski was on August 5 in 1987.[1] People could have been infected while slaughtering the animals. Another possibility is that mosquitos became infected after biting the animals and subsequently transmitted the virus to humans after the animals were slaughtered, and the zoophilic mosquitos had to turn to humans for a blood meal. A problem with this theory is the long interval between the date of Tabaski and the detection of the first case in the hospital on October 14. Interestingly, the feast of Tabaski also preceded the epidemic near Aswan in 1977.

Although the information is inadequate to explain completely the rift valley fever epidemics, a possible risk factor seems to be the occurrence of Tabaski at the beginning of the wet season when mosquito densities are high. This will not occur again for about three decades.

If the filling of the Diama Dam indeed was a main factor in the RVF outbreak in 1987 in Rosso, repetition seems unlikely since dikes have been built to prevent flooding of land that may have provided breeding sites for mosquitos. However, epidemics might occur near Foum Gleita and

[1] Tabaski is the Muslim Feast of Abraham or Ibrahim, also known as the Feast of the Sacrifice.

Manantali Reservoirs, or when the Full Supply Level is raised above the current 1.5 meter level at Diama Dam.

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Chapter 9: Diarrheal Diseases, Water Supply, and Sanitation

This chapter is a synthesis of epidemiological information on diarrheal diseases and the condition and extent of water supply and sanitation facilities in the basin, especially for those communities close to the river. The synthesis involved examination of a diverse group of small reports on diarrheal diseases. No basin-wide studies have been conducted in the basin on this subject; therefore, only fragmentary analyses could be made. The infrastructure was also meager, but existing systems were visited and their operation discussed with local personnel.

The first part of this chapter covers the diarrheal disease epidemiology. The rest of the chapter is divided into three parts: infrastructure in the Senegal River Basin, behavior regarding sanitation, and the urban area around Dakar. Dakar is already withdrawing water from the river, thus its large size will have an important bearing on future water management.

DIARRHEAL DISEASE EPIDEMIOLOGY

This section summarizes the occurrence of diarrheal diseases related to the main hydrologic features in the basin. Cholera epidemics can cause high mortality and spread rapidly through water and food contamination. Thus, cholera epidemics, one of the most striking indicators of deficiencies in water supply and sanitation, have been occurring in the larger population centers in the valley. Epidemics of cholera occurred in St. Louis and some of the larger towns in the Lower Valley in 1984, and near Rosso, Mauritania in 1987, the year after Diama Dam began operation. Thus, the provision of the large and stable Diama Reservoir was not sufficient to ensure a safe water supply to the residents in larger towns.

However, in some rural villages around Diama Dam, a demonstration project using windmills for village water supplies showed that wind conditions are satisfactory to power pumps located on improved wells, that local manufacturers can build and supply these water systems, and that they reduce the diarrheal disease incidence from 10 to 20 percent of the previous rates. Inspection in 1994 showed that 80 percent of these systems were operating satisfactorily in the Trarza Region years after installation. The creation of Diama Reservoir probably ensures a stable level in the underground aquifer around the reservoir, thus ensuring a steady supply for such wells.

Special mention must be made of the contamination of water supplies in the St. Louis and Richard-Toll areas, including diarrheal diseases and episodes of intoxication with industrial or agricultural chemicals. There have been poorly documented incidents in St. Louis in 1984 and in Richard-Toll in 1994. Evidence points to contamination due to the heavy use of industrial chemicals, agricultural biocides and fertilizers in the industries and intensive agricultural enterprises in the Richard-Toll area, specifically the Senegalese Sugar Company.

Furthermore, the explosive population increase in the Richard-Toll area, without substantial improvements in water supply, has created an unusually large potential for chemical contamination episodes, and for epidemics of cholera, typhoid, and other diarrheal diseases. This risk has, until now, been suffered mostly by the labor force of the sugar company and nearby agro-industries. However, as urban populations expand in St. Louis and Dakar, and as the lower Senegal River and

Lake Guiers are increasingly being used for supplying these large urban centers, the risks are being passed on to the major population centers in Senegal.

Given the nature of agricultural biocides and industrial chemicals, it is likely that there will be long-term carcinogenic and mutagenic health consequences, in addition to the more spectacular and easily recognized episodes of intoxication already seen. The warning signs from the two recent intoxication episodes should be heeded as indicators of the danger from the long-term effects of these chemicals when they reach urban water supplies. This is a major problem for plans to expand the water supplies of St. Louis and Dakar.

The most pressing condition in the Lower Valley is the increasingly overcrowded conditions, superimposed on previously inadequate water supply and sanitation infrastructures, which create a high potential for epidemics of cholera, typhoid fever, and other diarrheal diseases, especially in Richard-Toll.

In the Middle Valley, for residents of towns close to the river, significant improvements in the diarrheal disease situation resulted from river regulation. Before the construction of Manantali Dam, these villages experienced outbreaks of severe diarrheal disease every summer, first when the river stopped flowing and the only sources of water were pools or wells dug in the river bed, and second at the beginning of the rains and flood when the river was contaminated with surface run-off containing wastes accumulated during the long dry season, and when housefly populations became enormous (**Figure 29**). Fortunately, the elimination of the dry episode by river regulation also largely eliminated this annual diarrheal disease outbreak in the Middle Valley.

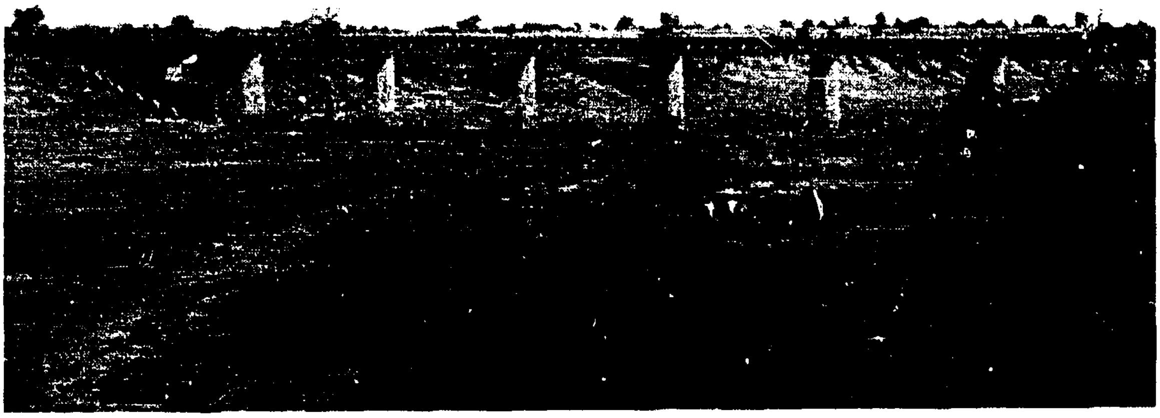
This was not the case for villages further from the river in the Middle Valley, however. These villages depended on surface ponds for water during the rainy season and on shallow wells during the dry season. With the reduction and sometimes elimination of the annual flood, the water table was no longer recharged each year, and the water levels in these shallow wells have dropped significantly, reducing the amount of water available to these communities in the Middle Valley.

Along the river in the Upper Valley, especially in the towns of Kayes and Bafoulabe in Mali, diarrheal diseases continued to be a severe problem despite regulation of the river. Diarrheal disease morbidity and deaths were among the top five health problems reported for the region of Kayes, including the towns of Kayes and Bafoulabe, and from a thorough epidemiological study in the Kita and Kenieba districts in Western Mali. Regional health authorities in Kayes saw no improvement after the regulation of the river; in fact, they felt that the conditions were worse.

After the construction of Manantali Dam, about 10,000 people were resettled downstream because their original villages were covered by the rising waters of the reservoir. A survey in 1994 showed that all of the resettled villages had access to potable water consisting of a bore hole with a pump. ~~For every 100 inhabitants, one water point was installed. This is significantly superior to the~~

Figure 29: Diarrheal disease outbreaks used to be related to river flows. The Faleme River at Kidira still goes completely dry each year *(a)* since it is not affected by flow from Manantali Dam, forcing residents to dig in the river bed for water which quickly becomes contaminated causing seasonal diarrheal disease outbreaks. When the initial flood comes, contamination from the rainfall runoff also causes severe disease *(b)*.

Figure 29: Les flambées de maladies diarrhéiques étaient liés auparavant aux courants du fleuve. La rivière Faleme à Kidira est encore complètement à sec chaque année *(a)* puisqu'elle n'est pas alimentée par le barrage de Manantali, forçant les habitants à creuser dans le lit de la rivière pour trouver de l'eau, laquelle se contamine rapidement causant des flambées de cas de diarrhée. Lors des premières inondations, les eaux de ruissellement sont également la cause de graves maladies *(b)*.



(a)

photos: Jobin

(b)

national standard (one water point for 200 people). These facilities ensure that villagers will have access to potable water all year.

In the dry season, most of the resettled villagers get their water exclusively from the bore holes or large diameter wells. During the rainy season, however, when natural ponds are created and when traditional wells fill up, villagers often use these traditional water sources, which are of inferior quality, rather than the pumped water.

In the area immediately affected by Manantali Dam, the new fishing camps along the Eastern shore of Manantali Reservoir do not suffer from diarrheal diseases because of the sparse populations in the widely scattered camps and the large amount of fresh water in the lake. Also, the resettled villages have been able to maintain their wells and pumps until now, reducing appreciably their former seasonal problems with diarrheal diseases.

In the uppermost reaches of the Bafing River Basin, gold mining may be causing water contamination that could be of public health concern. Several areas in Guinea and Mali have experienced contamination of public water supplies with heavy metals and cyanide, which is used in the refining process. Sludge from the mines and from refining is usually placed on the banks of the river, and then washed downstream with the first floods. This may eventually affect water quality in Manantali Reservoir.

INFRASTRUCTURE IN THE SENEGAL RIVER BASIN

Our general conclusion was that in the entire basin, the infrastructure for sanitation and the provision of potable water was inadequate, from the city of St. Louis to the smallest villages, as well as the population centers of Rosso, Boghe, Kaedi, Selibaby, Kayes, and Bafoulabe on the right bank, and Richard-Toll, Dagana, Podor, Matam, and Bakel on the left bank.

In the municipal water supplies, the quantity of water produced was insufficient. The treatment processes in the municipal centers appeared appropriate, but the average consumption of water was significantly below the norm. The peripheral zones of these communities suffered the greatest deficiencies. Provision of a safe supply exceeding 100 liters per capita per day is needed to prevent most diarrheal diseases and also to reduce bilharzia and other parasitic diseases. However, many of the municipal residents received only about 10 percent of that amount.

A careful epidemiological study of nine agricultural communities in a Study Zone of the Blue Nile Health Project in central Sudan, and of one village in St. Lucia, an island in the Eastern Caribbean, showed that provision of increased amounts of safe water resulted in the direct reduction of the prevalence of intestinal bilharzia (**Figure 30**). This reduction in disease continued with higher consumption rates, until the experienced consumption of safe water exceeded 70 liters per capita per day. No additional reduction in bilharzia prevalence was observed at higher consumption rates. Because of frequent interruptions in service of these village water supply systems owing to failures in the electrical power supply, shortages of diesel fuel, or equipment malfunctions, it was recommended that the systems should be esigned to supply 100 liters per capita per day. This design would actually supply the desired amount of 70 liters per capita per day.

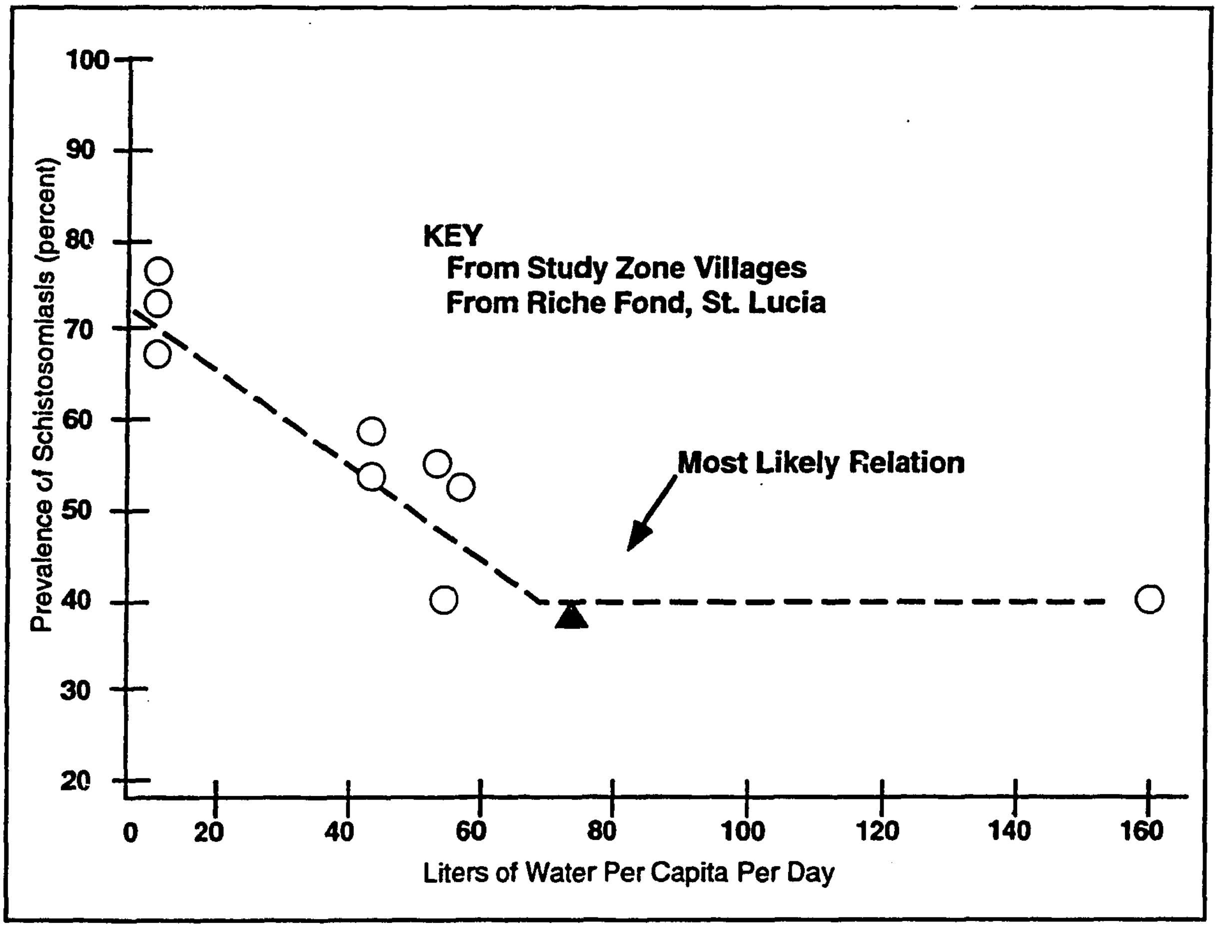


Figure 30. Increased Supply of Water Decreases Disease

A similar epidemiological evaluation of the effect of the consumption rate on diarrheal diseases showed that increased rates of safe water consumption resulted in decreased disease among children, even above the recommended rate of 100 liters per capita per day. This reinforced the value of the recommended rate. The observed link also indicated that it was the use of this water for additional cleaning, handwashing, and bathing that caused the reduction in diarrheal disease. This is an additional effect beyond the primary one of providing a safe water supply.

Health education must be used in parallel with the provision of ample supplies of safe water and must promote the use of this ample supply for personal and household cleanliness. Conversely, if an ample supply of safe water is not available to the family, health education will be ineffective, since children would not have the water necessary to carry out the recommended handwashing. General recommendations for lower design figures to supply 40 or 50 liters per capita per day are not sufficient in areas such as the Sahel Zone of Africa because of the severe problems with bilharzia and the scarcity of safe surface water.

River water, loaded with solid matter especially during the rainy season, could be filtered after sedimentation to provide an important source for future municipal supplies. Estimates for water demand by the year 2028 call for 48,000 cubic meters per day for Mauritania and 875,000 cubic meters per day for Senegal, representing almost 4 percent of the assured river flow from Manantali Dam. The municipal water systems must be expanded to permit consumption rates approaching 100 liters per person per day, with the ability to increase the rate as the population grows.

The number of village water systems was insufficient and the rural populations obtained water principally from traditional water sources, ponds, and the river. All of these were contaminated. Underground water could be further exploited upstream of Dagana if the recharge from the annual flood was restored. However, it seemed that on both banks downstream of Dagana, the river must be the future source for the rapidly expanding towns. Municipal systems should be extended to supply the surrounding villages. In all cases, the villages should have safe supplies that provide the same amount of water per capita as provided in urban centers, and within reasonable distances from homes.

Sanitation, sewer networks, and sewage treatment were also inadequate, usually completely absent, both in municipal centers and in the villages, despite the unfavorable nature of the soils and the high level of the water table.

e sewerage network must be extended throughout cities like St. Louis, and developed in the ...nser portions of other municipalities like Rosso, Mauritania, and Richard-Toll in Senegal. In other parts of these municipalities, individual sanitary facilities are acceptable if they are appropriate for the local terrain and water table, but the municipalities must then provide a service for the regular emptying of latrine and septic pits. Every water supply project must be accompanied by adequate measures for disposal of wastewaters and excreta.

This precarious situation in environmental hygiene explains why diarrheal diseases constitute one of the major causes of infant mortality in the basin. Furthermore, by using ponds and other polluted sources, the populations exposed themselves to parasitic diseases such as bilharzia and guinea worm. In Mali, in a study conducted by the MOH in the resettled villages in 1994, the researchers found that among children, cases of diarrheal disease are "frequent" (MOH/Mali, 1994). The researchers associate this problem with "the use of water from unacceptable sources" such as ponds, the river, and traditional wells. Although potable water is available in all of the villages, villagers often prefer to use the water from other sources. In addition, they concluded that while latrines exist in all of the villages, they are often neither adequately used nor maintained. The researchers explain these behaviors by the fact that villagers do not understand the relationship between water quality and sanitation, and health and disease. In the conclusion of the MOH study, the need for village hygiene education activities was underlined.

Our main conclusion was that the inhabitants of the river valley do not have an adequate supply of safe water and adequate sanitation. However, in addition to financial considerations, it is also necessary to evaluate the availability of the natural water resources, and to develop the fundamental and important role of general health education. Thus, the following is included on behavioral aspects of sanitation.

SANITARY BEHAVIOR

Strategies of populations for the disposal of their wastes and human and animal excreta have a direct effect on their health. Throughout the interviews held at community levels in the basin, it was concluded that there were insufficiencies in sanitary behavior of the people as well as in the infrastructure. The interview and observations relative to sanitation were conducted in villages in all three countries, as well as in the municipal area of Richard-Toll in Senegal.

In villages with Maure populations, family latrines are nearly nonexistent and people said that they defecate "behind the village." Feces from children were often thrown on the ground near the house. In cases where the river or canals were near the houses, the women threw the feces there. Women also said that usually the children urinated and defecated in the river or in canals. In every village visited, the livestock were kept near the houses. Animal excreta was observed all around the houses. We observed that infants often played in direct contact with the fecal material and with other wastes found on the ground.

In Mauritania and Senegal, in villages populated by Peuhl and Soininke people, many families had latrines or cesspools behind the house, including very simple although often not very clean structures. In those houses with latrines, the latrines were used mostly by the adults. The other members of the family often excreted "far from the village" or along the river or canals. Feces from infants were thrown on the ground, into the river, or into the canals.

Using our village interviews, we did not find important improvements in sanitary behavior after the operation of the dams. In general it seemed that, with the abundance of water in the river and canals all year, people had more of a tendency to use these places to defecate or for disposal of excreta of children, rather than going outside the village.

In Richard-Toll, the sanitary conditions were quite different from those in the villages. This town has experienced a population explosion owing to the agricultural development of irrigated sugar cane on an industrial scale. In 1994, the town had more than 50,000 inhabitants, and had grown without any rational development of water supply or sanitation infrastructure. Société Nationale d'Exploitation des Eaux du Sénégal (SONEES) served only about 20 percent of the town inhabitants with piped water. The river is quite far from most residential areas, thus the close accessibility of the canals explains why the majority of people used the canals for all their domestic needs and also for their animals.

Only a small number of the people in Richard-Toll had latrines in their homes. People interviewed said that adults preferred to wait until dark to defecate near the canals, while during the day they would use the neighbors' latrines. Chamber pots for collecting the excreta of children, and some adults, were emptied into the canals at night. Inspections discovered an abundance of excreta near the canals. Likewise, enormous amounts of household wastes were observed along the irrigation canals that crossed the town. Wastewaters, after having been used for cleaning and laundry, were then dumped in these same canals. At the same time, animals such as goats and sheep drank and were washed in the irrigation canals at the same place where people bathed and took water for domestic use. In general, these conditions, which we observed throughout the town, were ideal for transmission of water-associated diseases, including diarrheal diseases and bilharzia.

On the basis of interviews in the residential areas of Richard-Toll, people seemed to realize that it was not a good idea to dispose of their excreta in the same water that they used for domestic needs. However, they said there were no alternatives. The people interviewed said that the costs of connections with domestic water as well as the monthly charges were high. They said that many of them who had house taps used water from the canals as much as possible, given the price of water charged by SONEES. They also said that latrines were expensive and that the municipality did not help with construction. The doctor of the Senegalese Sugar Company said that at present the company was conducting discussions with the town authorities to try to develop a program to furnish potable water to all the inhabitants of Richard-Toll. He explained that the company was ready to finance part of the project.

In Mali, in the resettled villages downstream of Manantali Dam, both villages and individual houses are quite close together and almost all households have latrines. The construction of latrines was supported by the resettlement project. However, while individual household-level latrines are generally available, family members do not always use them. While the elderly and the sick use them exclusively, other family members sometimes relieve themselves in a pond or the river or near a well or water point. When questioned about the advantages of latrine use, villages primarily cited "easy access" and "privacy" as the factors that motivate them to use their latrines. Very few villagers identify "hygiene" or "family health" as advantages of latrine use.

INFRASTRUCTURE FOR THE URBAN AREA OF DAKAR

A major water supply system is under design to divert water from the Senegal River through Lake Guiers, and then to deliver water to the urban area of Dakar as well as cities along the way, after a high degree of treatment.

This system is being designed to supply 100 liters per capita per day of treated water to all the urban inhabitants. This is several times the quantity of water presently available to residents of the Senegal River Basin, despite the higher incidence of diarrheal diseases in the basin, and the presence of severe bilharzia related to inadequate water supply. The same general inequity exists in present and future sewer systems and sewage treatment.

Our review of health conditions around Richard-Toll, St. Louis, and Lake Guiers, namely the recent invasion by bilharzia snails and disease transmission and the episodes of intoxication by industrial and agricultural chemicals, indicated that these are also major risks for this proposed system for Dakar.

The general proposals for sewage collection and treatment for Dakar included a tendency to discharge sewage untreated into the ocean, or to give it secondary treatment before such discharge. One part of the sewage is being used for the irrigation of trees in the Dakar suburbs, but most of the flow was disposed of by a disorganized and poorly maintained system of drains.

Chapter 10: Primary Health Care Systems

Primary health care at a minimum involves health education, prevention and control of health problems, promotion of good nutrition, a sufficient supply of clean water and basic sanitation, maternal and child health protection including family planning, vaccination against infectious diseases, prevention and control of local endemic diseases, treatment of current illnesses and wounds, the provision of basic medicines, and community participation in the process of formulating health policies. For community diagnosis and development of action programs, emphasis is given to intersectoral collaboration involving education, agriculture, livestock, food production, water resources, environmental protection, housing, industry, public works, and communications.

In September 1987, the Bamako Initiative adopted by the World Health Organization Regional Committee for Africa emphasized accelerating the primary health care actions at the district level. Focus was given to a system of community financing based on the supply and sale of supplies (including report forms) and essential medicine. The goal was to provide universal access to primary health care for women and children. To reach the goal, the Bamako Initiative recommended substantial decentralization of decision-making to the health district level and management of primary health care at the community level, including financing and autonomy of primary health care. Rather than centrally managed, vertical programs, the Initiative emphasized the integration of primary health activities at the district and local levels with programs and plans developed to meet local needs. Community participation in decision-making and management would occur through district and village development committees and health committees.

PUBLIC HEALTH SYSTEMS

The basic health system in all three Senegal River Basin countries was inherited from the French. The system consists of a national ministry responsible, along with other national institutions, for centralized planning of the health sector and control of large health regions equipped with a public hospital, laboratory, and pharmacy. Regions are subdivided into departments with a medical doctor heading a health district with at least one health center that has limited hospitalization facilities and laboratory for analysis, and in some cases a maternal and child health center. Departments are administrative units headed by a commissioner and are subdivided into boroughs headed by sub-commissioners. Medical regions and districts generally follow the administrative structure, but regions and districts do not necessarily follow this structure.

Health posts, located in larger villages of 10,000 to 12,000 inhabitants within a 10-kilometer radius, are staffed by nurses, *sages femmes*, or health assistants generally having two years of training. Personnel are placed through the ministry of health regional public health system and work under the supervision of the medical doctor of the district or department.

PRIMARY HEALTH CARE DECENTRALIZATION

A major focus of the health systems has been on improving population coverage and accessibility of health care while increasing community participation and self-financing through the sale of basic medicines and supplies. In some smaller outlying villages of at least 200 inhabitants, health huts (*cases de sante*) and village pharmacies have been established where the villagers take charge of health problems. A number of local residents and traditional midwives were trained as community health agents through rural health projects. Rural maternity facilities are scattered throughout the countryside.

Primary health care strategies, which employ community health workers to serve the needs of their communities, have been adopted in Mauritania and Senegal with varying degrees of success (Rubinstein and Lane, 1990). Currently, there seems to be agreement that primary health care should be planned and delivered through district health systems because the district is a geographical and administrative unit large enough to be representative yet small enough to be manageable.

The Bamako Initiative laid the groundwork for a policy of decentralized planning and management of financial and human resources. Control is being shifted from national to regional level and district level and vertical programs are being synthesized into district programs. The World Bank's Project for Human Resource Development, Population, and Health has been a major force in carrying out the reorganization of the health district system in Senegal as well as in Mauritania.

MAURITANIA

The new organization of the Ministry of Health and Social Affairs in the Islamic Republic of Mauritania was adopted and applied in 1992 to improve coordination and integration of the different directions and services as part of decentralization, reduction of central administration costs, and integration of the different vertical programs. A Direction of Coordination of projects was established. The Direction of Health Protection coordinates the Regional Directions of Health and Social Affairs (DRASS). The public health system was decentralized to the wilaya level with the establishment of DRASS in 1989.

Primary Health Care Structure

Each DRASS has a Director, a Primary Health Care (PHC) Coordinator who oversees the vaccination program and health reporting system, and a regional pharmacy. Previously, the DRASS organization included a PHC and Hygiene and Sanitation division. These two divisions have been combined with Health and Hygiene being subsumed under the direction of the PHC supervisor. A DRASS covers several *moughataa*, or departments, each of which has a health center with limited hospitalization facilities, a maternal and child health program, and a maternity facility.

The right bank of the Senegal River Basin is divided into four health regions in Mauritania: Trarza, Brakna, Gorgol, and Guidimaka. A regional hospital is found in each with laboratory facilities and radio communication facilities. The WASH team visited the Trarza region. Part of the Trarza medical region is not ecologically part of the Senegal River Basin.

The Trarza DRASS includes six moughataa: Rosso, Boutilimitt, Rkiz, Mederdra, Ouad-Naga, and Keur-Macene. Boutilimitt has a polyclinic reportedly well equipped. Each health center supervises a number of health posts providing basic care in outlying villages. The ratio of population and health post ranges from about 5,000 inhabitants in Mederdra and 5,800 in Keur-Macene moughaatas to nearly 19,000 in Ouad-Naga. In its 1993 Annual Report, the Trarza DRASS reported that 27 health posts were functioning with 13 of these operating on the cost recovery system. In May 1994, the Primary Health Care Supervisor of the Trarza DRASS reported 22 functioning health posts and indicated only four of these did not have a cost recovery system.

The national primary health system in Mauritania is anchored on the concept of participative community management of health services inspired by the Bamako Initiative. Experimental PHC systems were set up in selected areas in 1988, including the Trarza region with the assistance of USAID. A total of 214 community health workers were trained in the Trarza region under these PHC projects. The Chef de Services de SSP, who has worked in the region for about eight years, estimates that currently about 80 or 90 of these people are still functioning in their communities, for the most part the women midwives, or *accoucheuses traditionnelles*.

Essential medications are made available to the health centers located in each moughataa, health posts in the larger populated centers, and the community health workers in outlying villages who sell the medications to the local people earning a small profit, which is split between the health worker and the community. The first stock of drugs was provided free of charge, and the community assumed responsibility for purchasing the new supply when needed from the revenue earned from the sale of the base stock.

The health worker is chosen from the local community, and a local health committee is organized in each village to oversee health affairs. The health worker in charge of the health post visited in the village of Birette has a very small stock of medications that he procures from the regional DRASS in Rosso and resells through the dispensary at the health post. He reports using the profits earned from the sale of these drugs to subsidize medicine for persons in the village who cannot afford to pay.

When the USAID projects finished, problems were encountered with the continuation of support including supervision and provision of medications. These projects provided the training of the community health workers and logistical support for supervision, including two vehicles. One of these vehicles has been discarded at the regional health office, and the second was returned to the Ministry in Nouakchott because it was not serviceable. The distances between health facilities in the region are very long, many more than 150 kilometers from the regional center, and the roads are very difficult. UNICEF has stepped in to support the vaccination program and has provided the only vehicle now available for the regional DRASS.

Currently, no supervision or follow-up is provided for the community health workers. For a while they were able to go to the Departmental Health Centers to procure essential medicines to resell in their communities. But because the supplies were not available to meet the demand, this support was discontinued. The community health workers then had to go to private pharmacies in Rosso to purchase the basic medications where the prices were reported to be ten times greater than those in the national health system. As a result, they had to pass on the higher costs to the rural inhabitants. The current priorities of the PHC are to ensure a continuous supply of low-cost essential medications to the health centers and health posts. The World Bank funded Project of Health/Population intends do this in the near future for the Trarza region. The vaccination program is the other PHC priority. This effort is supported by UNICEF after the termination of the USAID projects.

Hygiene and Sanitation

At present, there is little or no activity in the region of Trarza regarding hygiene and sanitation, health education, or other actions that would mitigate the problems of water-related diseases. In fact, there was no concern on the part of the Director of DRASS about an epidemic of schistosomiasis because no or few cases had been recorded by the health system. An Italian research group was scheduled to carry out a study in the region in June 1994.

No materials for health education of any kind were evident in the health post visited. The nurse indicated that it was difficult to carry out any health and hygiene education activities because the women were working in the fields. The Trarza PHC supervisor indicated that health education was carried out by Health Centers but not in lower levels of the health system. Concerning the Fight against Malaria, the PHC supervisor indicated that cases were treated when they came to health facilities, but no outreach program for prevention or education was in place.

Administration

There is minimal supervision of the health worker personnel in the health posts and health centers from the DRASS. The regional PHC supervisor visits each health center monthly to collect service statistics, and each health post every three months to collect data from the registers in each facility. The nurse at the health post visited reported that the regional pharmacy officer visited every two months to control the supply of essential drugs.

The UNICEF evaluation of PHC (1993) concluded that the policy of the past two decades, which prioritized strengthening hospitals in regional capitals, training community health agents in the rural communities, and developing exclusively preventive vertical programs that did not respond to the felt needs of the population, has accelerated the degradation of the health system with reference to the health centers and health posts.

Increasing budget restraints and the absence of materials and medications have further discouraged health facility personnel and users. In larger centers, private clinics and pharmacies, which have been allowed since 1983, have attracted many of the patients with financial means. The Director of DRASS has indicated that a major problem is the lack of sufficient training of the personnel staffing the health posts and the lack of trained personnel to staff the existing laboratories in the health centers in the region. The Director of the Trarza DRASS reports that more women are entering the health service and seek to serve in the larger centers. However, putting a woman in charge of a health post creates problems because of all the social problems she encounters. Several health posts are not staffed. A training needs assessment has recently been undertaken, and the Trarza DRASS Director expects training to take place starting August 1994 through the Health/Population Project.

SENEGAL

Primary Health Care Structure

During the 1980s, the Government of Senegal undertook efforts to streamline and decentralize activities. As part of this effort, the Ministries of Health and Social Action were joined into one Ministry of Health and Social Action. The number of directions was reduced from six to three with the other directions becoming Bureaus directly under the supervision and control of the cabinet. Until the recent reorganization, five ministries were involved in the health plan development process at the central level: the Ministry of Health, the Ministry of Social Action, the Ministry of Plan and Cooperation (now dissolved), the Ministry of Interior, and the Ministry of Social Development (now divided).

At the central level, the Ministry of Public Health and Social Action includes the Direction of Public Health, which directs the National Hygiene Service, the National Health Education Service, the National Maternal and Child Health Service, the Service of Alimentation and Applied Nutrition, the Primary Health Division, and the Division of Statistics. Vertical programs have been developed for the delivery of primary health interventions, most notably the Expanded Vaccination Program (PEV) mainly supported by UNICEF.

At the regional level, the chief medical officer of the region had to consult and develop plans with the aid of subordinate health center officers and the administrative officers (governor, commissioners, sub-commissioners, and the presidents of the rural councils); committees at the local, department, and regional levels; and councils at the local, borough, departmental, and regional levels. Usually most of these groups have carried out project planning decisions made at the central level and with the means provided by that level. This planning process has created confusion, cross-purposes, and conflict (USAID, 1990).

In June 1989, a National Health Policy set out the following objectives:

- Improving the health of women and children
- Developing preventive actions and health education
- Rationalizing curative activities
- Rationalizing the development of human, material, and financial resources
- ~~Mastering the demographic variables~~

The Human Resources Development Project (PDRH) financed by the World Bank is currently working to carry out the National Health Policy through three components:

- Establishment of the health district system

- Promotion of essential medicines
- Institutional reinforcement of the health sector

Health Districts

The health district system involves a decentralization of decision-making, including budget management. Each health district should have two doctors, a chief medical officer, and an adjunct, with a team of four supervisors: one for primary health care, one for the pharmacy, a specialist in maternal and child health and family planning, and a health educator aided by an administrator who is in charge of global accounting for the district and the health center. This administrator is also in charge of preparing the development plan of the health district.

Health centers are reference centers for the health posts and each of these facilities provides a standardized minimum package of services. Health centers provide hospitalization with a capacity of 100 to 150 beds, consultation with a physician, laboratory analysis and radiography, emergency surgical procedures, and nutritional recuperation. Health centers manage pharmaceutical supplies and financial accounts, and offer basic medicines, information, and health evaluation.

The basic services provided by a health post include primary curative care, caring for the chronically ill (e.g., tuberculosis and leprosy patients), prenatal consultations, family planning, and promotion of nutritional well-being. Health education at the health post level is not considered a separate activity but is integrated into all activities. Health post nurses are responsible for pharmaceutical and financial management working with the local health committee and for all health information data collection, including the registration of individuals, maintaining family dossiers, and keeping current health statistics as well as making visits in the villages. The chief of the health post can be a nurse, a *sage femme*, or a sanitary agent with appropriate training and assistants who are to be paid by the health associations. The minimum support staff consists of a secretary and one or two village manual workers.

When the minimum package of activities is carried out satisfactorily by a health post, activities can be extended to other actions such as health promotion. Health promotion includes nutritional education, and clean water and sanitation. These activities require resources greater than those of the health services; therefore, a principle objective is to inform and motivate the population to take action usually through the initiative of charismatic local leaders.

Health Committees

Health committees are being reorganized at the level of the health facilities as provided in the Government of Senegal Status of Health Committees (Decree 92-118, January 17, 1992). This ~~legislation provides that the members of the health committee are the population served by the~~ health facility, for example, a health post. The General Assembly of the Health Committee is composed of the heads of concessions or village groups, or their representatives, and the representatives of women's groups and youth associations.

Each health committee is represented by two bureaus: one (of seven members) for administration and development of plans of action, and one for implementation and budget management. Three

commissions have administrative, financial, health, and promotional functions. The revenues of the committee are generated from two sources: receipts from health consultation visits and assessments, and fund raising activities and outside financial support. The president and treasurer are co-signers of all banking transactions of the
committee. The nurse in charge of the health post retains the checkbook and coordinates and adapts the plan of action of the committee to the policy refined by the Ministry of Health.

Health District Health Associations

At the level of the department is a health association, represented by a general assembly elected by the health committees. The association is recognized by the Ministry of the Interior as the official body charged with the guardianship of the health committees. This association has decision-making power concerning information, training, education, evaluation, and supervision. The association has an executive committee elected by the general assembly for a two-year period. Monthly, the association receives 7 percent of the receipts of each of the health committees.

Health System Organization on the Left Bank of the Senegal River

The St. Louis medical region is an MSAS administrative unit with offices in St. Louis with a doctor in charge assisted by a doctor from Project ESPOIR, a supervisor of primary health, and a supervisor of maternal and child health. A regional health education office and hygiene service are located in St. Louis; a regional office of Grandes Endemies is located in Podor for the control of local endemic diseases, such as leprosy, malaria, tuberculosis, and AIDS.

At the departmental level are the health districts:

- Six in the medical region of St. Louis with the District of St. Louis (population 178,000) currently without a Health Center (a new one to be constructed), but with a doctor, six municipal dispensaries, and 14 health posts, four rural maternities and five health huts

- The medical region of Richard-Toll created in 1991 (population 71,314), with a public health center, a new laboratory, 12 health posts, and the privately owned health center of the Senegalese Sugar Company (CSS)

- The medical region of Dagana (population 55,042) with 10 health posts in addition to the health center, four rural maternities, and seven health huts

- The Health District of Podor (population 149,945) with the hospital of Ndioum, in ~~addition to the health center, the Regional Office of Grandes Endemies, a municipal~~ dispensary, 40 health posts, one facility sponsored by a catholic charity, 22 rural maternities, and 47 health huts

- The medical region of Matam (population of 245,342) with the Hospital of Ourossogui, the health center, 41 health posts, 15 rural maternities, 10 health huts, and a municipal dispensary

A large number of these facilities are located near the main road RN2, which runs from St. Louis to Bakel, or closer to the river.

In the Department of Bakel, there were two health centers in the commune of Bakel and a total of 18 health posts in the boroughs (administrative sub-divisions of a Department) of Kidira and Diavara, which are taken into consideration as part of the Senegal River Basin (OMVS/UNDP, 1991). Hygiene and Sanitation brigades are attached to the District and work under the doctor in charge. Health education personnel were trained to work at the district level but are highly mobile often leaving the posts vacant (MSAS, 1993).

The organization and start-up of the health committees to work with the health facilities is taking time as each health post committee must send to the Ministry of Health and Social Affairs in Dakar a dossier including a letter from the President of the Committee requesting recognition, four copies of the Statutes, four copies of the Proces-verbal of the Constitutive Assembly with the composition of the elected Bureau (President, Vice President, Treasurer, Assistant Treasurer), the approval of the health post chief, plus four fiscal stamps worth 1,000 CFA each. The Ministry of Health and Social Affairs forwards the dossiers to the Ministry of the Interior, which provides official legal recognition of the committee allowing it to open a bank account or postal account. It often takes six months for a dossier to be processed.

Health education materials about the formation and functioning of the health committees refer to the eight key activities of primary health care outlined at the Alma Ata World Health Conference of 1978. This booklet emphasizes that health committees promote and ensure sustainable health education activities, promotion of good nutritional conditions, sufficient clean water and sanitation facilities, maternal and child health including family planning, vaccination against serious infectious diseases, prevention and control of local endemic health problems, treatment of common illness and wounds, and provision of essential medicines.

Since 1992, a test program for the reinforcement of Primary Health Care delivery has been supported by UNICEF in several test districts including Podor, Matam, and Bakel. Emphasis has been placed on the logistics of ensuring a supply of basic materials including essential medications, vaccinations, and equipment and management improvement relating to planning, monitoring, and covering the vaccination program, prenatal care, and curative care.

UNICEF has introduced a flow-chart based on clinical signs and reported symptoms to improve the prescription of essential medicines and an additional monitoring of activities at health post level to assist in microplanning of health post activities.

In principle, supervision is desirable every two months but monitoring meetings now take place every six months to examine all health post activities concerning the vaccination program, prenatal activities, curative consultations, and financial monitoring and to develop microplans to improve delivery for the following period.

The UNICEF monitoring system emphasizes quality of service delivery, unlike the MSAS monitoring system, which emphasizes coverage. Training is provided to health post personnel to graph data by hand to show progress being achieved in coverage, for example. The data from the test district monitoring are also computerized for comparative analysis. Plans have been made to transfer data processing and analysis capacity to each district. Hardware and software are available at UNICEF headquarters awaiting scheduling of the training of three persons from each of the test districts in the use of the systems. To date, the MSAS has delayed this training and implementation of computerized data handling at the district level.

Since 1988, the European Community has engaged in a health project as one aspect of the Program of Support to the Development of the Region of Podor. The goal of the health project has been to ameliorate the services of the basic health structures by providing logistical means to carry out their mission. Vehicles have been provided and buildings have been refurbished. Management training and assistance has been provided to health personnel especially as relates to the problems posed by the local endemic diseases. The fight against malaria and schistosomiasis, diseases related to the extension of the hydro-agricultural perimeter, are two priorities, as is the fight against sexually transmitted diseases and AIDS. Education is at the base of the water, health, and hygiene program that focuses on a better use of potable water. Bore holes and modern wells have been developed in the department of Podor equipped with approximately 130 solar pumps.

The European Development Fund is now working throughout the whole Medical Region of St. Louis in conjunction with the World Bank in the area of training and education and the development of the health districts. In addition, the European Development Fund continues infrastructure development with the planned construction of 46 health posts in the departments of Podor and Matam and an urban dispensary in Richard-Toll. Additional equipment for the hospitals of Ndioum and Ourossogui and the health centers of Podor and Richard-Toll has been planned. Community water projects will be supported.

ORSTOM and Project ESPOIR have been concerned with the epidemiology of malaria and schistosomiasis in the valley and have funded research on the left bank as well as established a new laboratory at Richard-Toll. Project ESPOIR has also supported the development of some health education materials concerning schistosomiasis.

The major concern in the St. Louis medical region is malaria and its potential spread with the increase in irrigated perimeters. In addition to the prescription of chloroquine, a program to encourage the use of bed nets impregnated with deltamethrine is planned for the departments of Matam and Dagana. UNICEF has undertaken a program for the eradication of guinea worm disease which in 1993 was reported to affect about 12 villages in the Arrondissement of Semme in the St. Louis medical region with an estimated population of 3,498 inhabitants. In 1993, training was provided for the Podor and Matam health post nurses in the treatment of diarrheal diseases, and a supply of rehydration salts was made available to them.

Since 1986, the World Health Organization has sponsored an extensive program to control river blindness, which reaches into the eastern region of the Senegal River Basin. The activity is carried out by personnel assigned to the project.

In Senegal, a small number of health system personnel are now being called on to implement a wide variety of activities under the integrated primary health care concept. The many donors that previously sponsored vertical programs and worked with their own personnel are making demands more and more on the time of limited human resources at the district and health post level for participation in training, implementation, and the reporting of activities.

MALI

Primary Health Structure

The Ministry of Health, Solidarity, and Aged Persons is currently supported by the *Projet Sante, Population et Hydraulique Rural*. The structure of the Ministry includes the *Direction Nationale de la Sante Public*, the *Direction Nationale des Affaires Sociales*, and the *Institut National de Recherche en Sante Publique (INRSP)* on the same level of organization.

The INRSP is carrying out the monitoring of health impacts for the Selingue Dam Project. Vertical programs continue to function for endemic disease control, notably the guinea worm disease and onchocercoses national programs. The guinea worm program undertook a comparative community-level survey in 1991 to identify endemic communities and has field workers to undertake health education and the distribution of filters, as well as the monitoring of prevalence in areas where the disease exists, including the Kayes region. The OCP is now carrying out community treatment with ivermectin in large villages in areas at risk. Community workers are trained to distribute the drug to local residents yearly.

The region of Kayes covers the OMVS region of interest with medical *departments* (the equivalent of departments) each headed by a chief medical officer. Each department has a health center and, in some cases, a hospital. New hospitals were recently constructed and equipped in Bafoulabe, Kita, and Kenieba with World Bank project assistance. In addition, the boroughs have dispensaries run by nurses or health technicians and rural maternities with a matron as in Bamafele. In addition, some villages support community health centers or health teams that are outside the fiscal support of the Ministry. The health infrastructure of the Cercle de Bafoulabe includes the Centre de Sante at Mahina where the train station is located and Centre de Sante d'Arrondissement in Bafoulabe, Bamafele, Diakon, Diallan, Goundara, Koundian, Oualia, and Oussoubidiagna. All of these health centers include a dispensary and maternity; only half were judged in the 1993 report of the department as being in a good state; the other half were in poor condition. At Manantali, the OMVS supports a health center staffed by a doctor and a nurse.

The 1980-1990 Health Development Plan was based on the Primary Health Care objectives of providing children's immunization against measles, meningitis, tetanus, and so forth, eliminating all forms of malnutrition and controlling major endemic diseases. Emphasis is now being placed on a system of supply of essential medicines on a cost recovery basis. There is also a current emphasis on maternal and child health and family planning. The guinea worm program and the OCP are also active at the community level in the Manantali, Bafoulabe area of the region of Kayes.

Decentralization is being undertaken with the department as the operations center for managing health development activities. Health coverage is being extended by the development of community health centers based on community financial and decision-making support.

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Chapter 11: Health Information Systems

WHAT HEALTH INFORMATION IS NEEDED?

The Bamako Initiative of 1987 suggests that a good information system for primary health care management should be a system that will furnish valid information at the opportune moment concerning:

- The intentions (e.g., vaccination, growth monitoring, rehydration)
- Use of medications
- Frequentation
- Community participation (e.g., decisions, management, meetings, and activities)
- Financial systems
- Demographic statistics

Others recognize that basic information needed for health planning answers the following questions:

- Who dies? Of what?
- Who is sick? From what? Why? (Sambous, 1994)

Valid and timely statistics on disease prevalence are the bases for appropriate curative care as well as health education for prevention and control. Currently, the public health systems have devised routine data collection operations, one part of which seeks to classify the pathologies of patients using the health facilities.

Much additional information related to health facility coverage, accessibility and use, and preventive actions, especially vaccination coverage, prenatal examinations, family planning, and the growth monitoring of children, is also collected. A major concern is estimating the population within a given distance from the health facilities in order to calculate target populations. A small amount of information is requested from some facilities concerning health education activities and water and hygiene conditions within the communities served. In addition, basic medicines are inventoried and in some cases financial accounts are reported.

PUBLIC HEALTH INFORMATION SYSTEM IN MAURITANIA

In 1991, the Ministry of Health and Social Affairs undertook a complete reform of the Mauritanian health information system. New, simpler forms have been produced for reporting service activities and epidemiological data from the health post level on up. A computerized data entry system based on the new forms has been set up in Nouakchott. However, many problems remain with data and information flows and basic diagnostic capabilities.

Communication between health facilities and the regional DRASS is very difficult. There are no telephone or radio communications. In the case of reportable contagious diseases or emergencies, the nurse from the health post notifies a local commissioner or sub-commissioner who then communicates by radio to the regional DRASS. For less urgent matters, the best way to communicate with a distant health post, according to the Trarza PHC supervisor, is to send a letter via the local cars that travel daily from the regional capital to the outlying towns.

Visits from the PHC regional supervisor take place monthly to the six health centers in the Trarza Region and every three months to the 22 health posts to collect routine service statistics from the registers maintained in each facility. According to the PHC chief, each health post fills out forms in triplicate, retaining one for its own archives, and sending one to the health center of the department and one to DRASS, which is transmitted to the epidemiological department in Nouakchott and then on to the statistical division. DRASS retains no data at the regional level.

At the national level, data are being computerized using a database program developed by CERPOD, Mali to provide for easy data entry from the data collection forms that are currently in use throughout the system. Sources have indicated that these blank forms were unavailable for about six months, thereby impeding the flow of information. The epidemiologist also indicated that information is received from only some health facilities in the regions. There is a large time lag in collecting data, data entry and processing, and the presentation of statistics. Epidemiological data from 1992 have just been published with all figures aggregated to the Wilaya and national levels with yearly totals. No sub-regional disaggregation of the epidemiological data with seasonal variations has been presented.

The weakness of diagnosis of illnesses is a major problem as health posts are not at all equipped and many of the health centers do not have functioning laboratories to confirm diagnoses made in the department. Categories of diseases in the new reporting forms may be confusing at the health post level; for example, distinguishing "dysenteries/amibiases, diahree Gastro-enterites, parasitoses intestinales." Diarrhea may also be a symptom of other diseases, notably cholera and intestinal schistosomiasis. The current nosology reporting scheme does not distinguish between intestinal and urinary schistosomiasis. The latter may be recorded as urinary track infection.

In addition, only cases of persons coming to the health facilities are included in these statistics. A 1991 study by UNICEF in eight villages without a health facility found that more than 80 percent of those with serious illness did not go to a medical facility (UNICEF, 1992). Data from private clinics or consultations are not included. Neither are cases of self-medication nor consultations with traditional healers. Activity reports from sentinel centers located in the experimental zones of the national program of primary health inspired directly by the Bamako Initiative provide additional information. Growth monitoring is undertaken at maternal and child health centers and nutritional education and recuperation centers but not routinely at health posts.

The 1988 census estimated a mortality rate of 19 per 1,000 and an infant mortality at 144 per 1,000. Special studies often provide more reliable information. In 1991, an MSAS/*Association Francaise des Volontaires de Progres* survey in the Wilaya of Gorgol estimated the infant mortality rate at 176 per 1,000. Maternal mortality rates are estimated from 1987-1990 hospital data to be 565 for every 100,000 births (UNICEF, 1992). Health system data indicate that the four most common diseases related to child deaths are diarrheal diseases, acute respiratory diseases, measles, and malaria. Mortality is difficult to quantify because of the low utilization of health services, especially for infant diarrhea. In 1985, malaria was estimated to be responsible for 15 percent of deaths, all ages considered together, related to communicable diseases. The rate would be expected to be higher for young children who have not developed immunity.

INFORMATION EXCHANGE FOR WATER

The Trarza Director of DRASS indicated that he participated in the *Commission Regionale de Gestion des Eaux des Barrages* in which SONADER, Agriculture, and Livestock regional personnel also participated. Created by the State of Mauritania, this Commission makes recommendations on water provision between the Rosso and Diama dams. The Commission can be convened by any sector and can ask OMVS to furnish water or not to certain areas currently provided with infrastructure. The Rosso OMVS Control Center makes proposals for the management of water, which are forwarded to the *Commission Permanent des Eaux* at Dakar. Water invoices for users are produced at Rosso but are paid to Dakar, *Haute Commissaire*.

THE HEALTH (MANAGEMENT) INFORMATION SYSTEM IN SENEGAL

Considerable effort has been made by the MSAS to diagnose its information needs and to develop and execute a strategy and action plan aimed at the long-term goal of modern management of the health sector. New reporting forms for health posts and health centers have been created and tested for the past two years in several districts, including Podor, where personnel have provided input and assisted in the revision of the system. The most recent version of the *Systeme d'Informations a fin de la Gestion* (SIG) forms are being produced as a booklet with self-carbons and being distributed to the health districts on a cost-recovery basis. A reference manual has been produced and training in the completion of the forms is being scheduled. The new SIG is not yet being used in the SRB region, with the exception of Podor.

Data on morbidity and mortality are included at the end of the new SIG report forms. It should be noted that information concerning morbidity and mortality from the Cases de Sante, where health care is provided by community health agents, is limited to reports of cases of diarrhea, fever, and other (but not combined) symptoms.

Nurses at the health posts are required to provide a nosology report listing 75 diseases, the majority of which should require laboratory confirmation. For example, diarrheal diseases are to be differentiated as either bacillus dysentery, amoebae, undefined intestinal infections, infectious diarrhea, or intestinal parasites. Cholera is another possibility. In some cases, the diseases have been replaced by symptoms, as in the case of syphilis and gonorrhea, listed in previous reporting schemes. It is difficult to report cases with multiple symptoms.

Notably missing from the most recent version of the SIG is the list of the 10 most common causes of morbidity for the month for consultations at the health post or health center. This information is probably one of the most important pieces of information for epidemiological surveillance as well as for health post planning for pharmaceutical supplies and health education and prevention activities.

Note that the final suggestion for the *tableau de collationnement journalier* represents a practical approach to data collection at the health post level. The example provides ideas of the types of health complaints that a nurse at this level could be expected to record reliably (e.g., cough, vomiting, diarrhea, headache, dental complaints, and constipation).

Suspected cases of important contagious diseases, such as cholera or typhoid fever, are reported immediately to the district and regional public health officers usually via telephone or radio from the local administrative office. Mass campaign prevention materials for controlling serious contagious outbreaks are currently stockpiled in a regional warehouse.

Health posts complete monthly report forms that are sent to the *Circonscription Medicale*, the Health District, where the data are aggregated and tabulated by hand for a District level health report every six months, a copy of which is provided to the Commissioner and to the regional public health office. There the regional supervisor of primary health aggregates district level data and produces an annual regional report.

A copy of district semester reports are forwarded to the national public health department of statistics where data are being computerized. Computerization is also being introduced at the regional level in St. Louis under Project ESPOIR tutelage. Epidemiological bulletins and compendiums of health statistics have been produced in several other regions. At least two projects are currently planning to introduce computers at the district level (UNICEF's IB Project for Podor, Matam, and Bakel) and the WHO SIGeo Project for Districts in the Region of St. Louis.

Existing data are difficult to locate and use. For example, information about trends in reported cases of malnutrition and diarrheal diseases in the SRB were sought. In the District of St. Louis, district level reports were found for 1985 and 1987 through 1993, which allowed the calculation of total reported cases of malnutrition and aggregated nosological categories for diarrheal diseases. Data by health post or by month were not archived; this would have allowed a study of seasonality or the pinpointing of local conditions related to these problems.

In the District of Richard-Toll, files for the last four years were found for each of the 12 health posts with original nosological data sheets recorded on a variety of forms and often as handwritten lists on random pieces of papers. Most of these reports do not include totals of cases or consultations; therefore, work was involved to locate data sheets and then total the number of cases of diarrheal diseases from several categories and across age groups, in addition to totaling all consultations. The spottiness of reporting was apparent.
The usefulness of the existing health information system data must be weighed against the effort of locating, organizing, processing, and analyzing what is available.

For epidemiological analysis of pathologies related to local environmental conditions, the only really useful health system data are kept at the health post level in the form of patient registers where cases may be tracked to village of residence and then field workers can assist community members to locate vector habitats, sources of contamination, practices detrimental to health status and so forth.

The health information system in Senegal remains cumbersome and data-heavy. A series of recent management information studies has shown that:

- The multitude of reporting systems which exist from the health hut level to the national level generate numbers that are not generally useful because they are incomplete, of variable quality, unstandardized, often late, and unrelated to the calculation of pertinent indicators.

- There is a lack of adequate training, supervision, and motivation of field personnel, frequent absence of basic supplies and rare feedback of analyses, interpretations, and recommendations to those who generate the data from day to day.

- At the national level there is a lack of coordination of the departments that collect and analyze data; this has resulted in the lack of a reasonably functional system for the analysis, interpretation, dissemination, and archiving of health statistics (USAID, 1990).

These problems will continue to exist with the newest version of the SIG being implemented. The problem of data validity of the expanded nosology reports is of special concern in terms of the current interest in epidemiological surveillance.

UNICEF HEALTH POST MONITORING SYSTEM

Since 1992, a test program for the reinforcement of Primary Health Care delivery has been supported by UNICEF in several test districts including Podor, Matam, and Bakel. Emphasis has been placed on the logistics of ensuring a supply of basic materials including essential medications, vaccinations and equipment, and management improvement relating to planning, monitoring, and covering the vaccination program, prenatal care, and curative care.

Under the Bamako Initiative Project, UNICEF has introduced a flowchart based on clinical signs and reported symptoms to improve the prescription of essential medicines and an additional monitoring of activities at health post level to assist in microplanning of health post activities. In principle, supervision is desirable every two months, but monitoring meetings now take place every six months to examine all health post activities concerning the vaccination program, prenatal activities, curative consultations, and financial monitoring, and to develop microplans to improve delivery for the following period.

For reporting curative care coverage, this monitoring system uses a sample of 30 patients (consultants), the data for which are recopied to a new form complete with patient's name, an indication whether they received a treatment, whether they paid the entire cost of a prescription within 72 hours, whether the signs and symptoms corresponded to a prescribed medication following the flowchart guidelines, and whether this treatment was in fact given. UNICEF emphasizes that this monitoring system is concerned with quality of service delivery, unlike the SIG, which emphasizes coverage.

While data can be graphed by hand by health post personnel to show, for example, progress in the vaccination program coverage, the data from the UNICEF test district monitoring are computerized (Compaq PCs and Paradox database with menu-driven data entry and outputs). Plans have been made to transfer data processing and analysis capacity to each district. Hardware and software are available at UNICEF headquarters awaiting scheduling of the training of three persons from each of the test districts in the use of the systems. To date, the MSAS has delayed this training and implementation of computerized data handling at the district level.

Work on Health Information Systems in Senegal should be aimed at simplification and reporting at the level at which peripheral health post workers can provide valid, useful information. This would leave these people time for the "real" PHC activities: health education and community mobilization for preventive actions.

If the reporting system were simplified to reflect the level at which health post personnel could report valid and reliable data based on clinical signs and develop an improved system for laboratory analysis of samples for more precise diagnosis, the nosology reporting could be greatly improved in terms of accuracy and usefulness. In addition, more health posts might be inclined to report regularly. These forms and indicators should be revised and simplified as the regions and districts gain further experience about what is really feasible and useful for their information needs. The simplification of the reporting forms could be tackled by the district level health associations, which are made up of health post representatives. Additional problems of health service reporting often mean that its statistics only identify the tip of the iceberg.

The lack of reports from health posts may be due to the fact that health posts are not always staffed. Paramedics are transferred and the posts left vacant and at other times the nurses may be away, officially or unofficially. In addition, report forms have not always been available. Many examples of nosology reports from health posts that have been handwritten on ordinary notebook paper can be found in district archives. Only cases that present themselves to public health facilities are reported. This usually underestimates health problems. In other cases, health centers and health posts located along the river see patients who cross the border from the right bank to seek treatment. Statistics on health problems in the district, as well as coverage, are increased artificially.

In terms of disease surveillance, the health system is largely crisis-management oriented, looking mainly to cure the patients who seek their attention. Even then, a major problem is that laboratory diagnosis is not carried out for the majority of cases seen in the health system facilities. In addition, the lab technicians are prepared only for routine examinations and may miss new cases of important diseases. With the major exception of the vaccination program, the current health system is not proactive in anticipating possible epidemics on the basis of predictable conditions and able to intervene to control these conditions and, thereby, prevent major health problems.

EPIDEMIOLOGICAL SURVEYS

Special epidemiological surveys often provide more timely and valid data about the health status of a population. Such studies have been undertaken by ORSTOM and Project ESPOIR concerning malaria and urinary and intestinal schistosomiasis. UNICEF has a project to eradicate dracunculiasis, and WHO monitors and fights onchocerciasis in the upper SRB valley.

PUBLIC HEALTH INFORMATION SYSTEM IN MALI

Monthly reports from the borough level dispensaries and health facilities are forwarded to each department where the data are aggregated to the level of the department. In Bamafele, the health facility was reporting for a list of 23 diseases on a handwritten sheet. Separate reports are filed monthly for vertical programs such as dracunculoses and onchocercoses. A laboratory for analysis exists at the level of the department in some cases.

Each month every *medecin chef du cercle* is responsible for filling out four copies of a health report; he keeps one and sends three copies to the Regional Director. Two copies are then forwarded to the National Statistics Department, which keeps one and forwards one to the *Division Sante Familiale and Communautaire.*

Funds have not been available for field supervision of the health data collection for 1993 until now. In the Bafoulabe Department, the chief of medicine reports visiting each of the health facilities but no meetings of all health workers are held because of a lack of travel funds. The monthly data are being computerized in Bamako, with only an approximate delay of four months. The plan is to decentralize the data processing to the Department level with assistance from the *Canadian Programme d'Appui a la Surveillance Epidemiologique*. Health planning is being undertaken at the level of the department.

A yearly annual compendium of information is published, with 1993 data just being released. Previously, 1989 data were analyzed and presented with graphics by region.

ENVIRONMENTAL AND SOCIO-ECONOMIC INTEGRATED DATABASE NEEDED FOR A USEFUL HEALTH SURVEILLANCE INFORMATION SYSTEM

Epidemiology aims for an understanding of how the well-being of humans is directly affected by their physical, social, and cultural environment. Reported cases of diseases are the outcome of dependent variables to be explained by epidemiological models, which use a holistic perspective encompassing environmental factors, biological parameters, human attributes, and social resources as independent variables. Single factorial models are not sufficient.

In the case of water-related diseases in the Senegal River Basin, a number of environmental, demographic, socio-economic, and sustenance activities have been identified, which are linked to health outcomes and well-being in an interrelated ecological system.

EXISTING INFORMATION SYSTEMS WITH AVAILABLE DATABASES RELATING TO ENVIRONMENT AND HEALTH

Several integrated databases and geographic information systems bring together some of the variables being developed.

Dr. Isabelle Nuttall of WHO, *Division de la Lutte Contre les Maladies Tropicales*, Geneva, is developing the new *Projet d'Integration des Donnees Environnementales et Sanitaires dans Un*

This SIGeo information system will focus on the relation of environmental conditions and water-related diseases including schistosomiasis, malaria, diarrheal diseases, and dracunculiasis in the St. Louis Medical Region. Disease data will come from the routine public health statistics but epidemiological survey data can also be incorporated. Data on hydrology, topography, soils, and vegetation will be included in addition to the location of villages of 2,000 plus inhabitants and health facilities. Administrative boundaries have been provided from the SIGRES system (Atlas GIS format) and health posts have been localized. See **Table 7**.

These data are to be transferred to MacIntosh MapInfo format because the WHO project plans to provide MacIntosh computer systems to each medical district in the St. Louis region. Hands-on training of the regional medical personnel on the use of the system took place in July and August 1994. In the future, data on hydrology including the river and tributaries, flood zones, swamps, bore holes, modern wells, and roads will be included in addition to agricultural zones and irrigated perimeters, schools, and village population from the last two censuses.

This WHO SIGeo project is being assisted in its set-up by the *Centre de Suivi Ecologique* (CSE). The CSE GIS uses ARC/INFO software. NOAA data are received daily, but the scale is difficult to use for monitoring changing ecological conditions at a useful level relating to SRB environment and health. SPOT photos used by the FAO village forest project in 1991 allow general areas of irrigated perimeters to be distinguished.

The *Systeme d'Information Geographique sur les Ressources en Eau du Senegal* (SIGRES), created by the PNUD Project *Planification des Ressources en eau*, and located at the Ministry of Hydrology, has computerized maps of all of Senegal with population and village location, as well as location of boreholes, modern wells, and the type of equipment of each. This information concerning the availability of safe water supplies and population distribution is of great potential use for a health information system. It is planned to incorporate some of this into the SIGeo. The PNUD consultants work with the water planning project previously set up a system in Mali; therefore, similar GIS data for the OMVS region in Mali also exist in computerized form at the DNHE.

The OMVS's GIS system uses ARK/INFO and tele-imaging inputs. Existing databases include information on irrigated perimeters with production data through 1992, villages, roads, and environmental factors including water levels, zones inundated by the 1988-1989 flood, rainfall, and so forth in the SRB.

ORSTOM, *the Institut Francais de Recherche Scientifique pour le Developpement en Cooperation, Eau et Sante* has developed a computerized mapping system of socio-economic data and health variables focusing on the prevalence and intensity distribution of *Schistosomiasis mansoni* for Richard-Toll. They are currently transferring a version of the system to Richard-Toll and have plans to use data from the CSS and MSAS health centers daily to track the origin of cases of schistosomiasis and perhaps other water and sanitation related diseases.

The challenges of GIS systems are the maintenance of data sets: keeping information up-to-date; sharing and combining data with other systems to increase the pool of variables and improve usefulness; and having the data used for improved rational decision-making.

Table 7. Proposed OMVS Integrated Information System Dimensions for Monitoring Environment, Health, and Nutritional Well-Being in the Senegal River Basin

Environmental Variables Related to Vector Habitats, Water-Related Diseases, and Crop Water Requirements
• Rainfall - amount and duration • Water Sources (surface water, pond, marigot, canal, river, cistern, active and abandoned irrigation facilities) - Water quality (potable and nonpotable), turbidity, pH, salinity, biological and chemical pollution - Physical movement of water bodies - water flow, turbulence - Aquatic vegetation • Climatic data - Air temperature - Humidity
Demographic and Socio-Economic Variables Related to Health and Nutritional Well-Being
• Population density and growth • Population movement - migration, resettlement, travel • Settlement location vis-à-vis water sources - Population pressure on water supplies • Level of living - Quantity of clean water consumed per inhabitant - Availability and use of sanitation facilities - Nutrition - food security and diet • Sustenance activities - Type and intensity of cultivation (irrigated, rain-fed, recession agriculture) - Livestock husbandry - Fishing - Commerce
Health Inputs
• Health facilities • Environmental control (e.g., spraying) • Use of barriers (e.g., mosquito nets and filters) • Information, education, and communication activities - Hygiene and sanitation practices - Diarrheal disease control (e.g., oral rehydration education)
Health Outcomes
• Prevalence rates of water-related diseases including malnutrition (measured as high, medium, and low)

An important potential use of the GIS village and population data included in the SIGRES system would be to assist health districts delineate population targets for health facility coverage and for the planning of new facilities and activities. If the basic estimated population statistics were available in a district computerized system, the monthly calculation of coverage, accessibility, and use could be routinely calculated from the monthly service statistics and reported back to the health workers with comparative data from the other facilities, with a great deal less work. In addition, local statistics on water and sanitation could be correlated with health outcomes, and health education could be targeted to specific areas or communities with high-risk conditions.

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VOLUME 2

RECOMMENDATIONS

Volume 2 of the Senegal River Basin Health Master Plan Study summarizes the broad issues involved in OMVS' management of the resources of the Senegal River Basin. Volume 2 also includes recommendations for controlling water-related diseases in the basin through general management, institutional, and engineering improvements.

Chapter 12: Basin Development and Issues in Resource Management

RESOURCE DEVELOPMENT

The development activities emerging since the creation of the OMVS have focused mainly on water control and have had a significant effect on the Senegal River Valley environment, especially since the building of the Diama and Manantali dams. The analysis in this chapter focuses on the effects on the environment of exploiting water as the main resource. In addition, the guiding principles for an integrated management of resources are stated.

Both dams have introduced deep changes in the natural environments:

- Traditional socio-economic patterns have been upset, especially agriculture.
- River flows have been moderated and will be further changed when power production starts.

The Manantali Dam

The Manantali Dam, on the Bafing River, is 90 kilometers southeast of Bafoulabé and 1,200 kilometers upstream from the river mouth at St. Louis (**Figure 31**). The dam was designed to withstand the exceptional floods that take place every 10 years. It should also permit the irrigation of 375,000 hectares in double cropping and sustain the low-water flow level of about 300 cubic meters per second for navigation.

The Manantali Power Project initiated by the OMVS has two components: the implementation of the Manantali power plant and the construction and equipment of 1,500 kilometers of electric power transmission lines. The project will introduce noticeable modifications in resources and environmental management. These changes will be linked to the operation of the power plant and the constraints it imposes on the Manantali water releases.

The electric power plant that will be built at the base of the Manantali Dam will be equipped with five Kaplan turbines for a total power of 200 megawatts (each turbine supplying 40 megawatts) and an energy output of 800 gigawatt-hours per year. The water volume supplied from the upper basin has been significantly modified by the barrier effect of the dam and by the management of the water releases needed to maintain the other functions of the river's waters.

The Diama Dam

The Diama Dam, 26 kilometers from St. Louis, began operation in November 1985. Diama Dam prevents the intrusion of sea waters during the low-water level period, creates an artificial lake of fresh water upstream from the dam, and allows for the filling of the Delta depressions at Lake Guiers and Lake Rkiz, and the Aftout es Sahel.

THE IMPACTS OF CURRENT MANAGEMENT

The effort made by the OMVS for mastering the management system and tools is laudable, but they still have not managed to solve numerous problems linked to organizational or technical factors.

There has been a lack of coordination between the users and the managers of the hydraulic works. Since the completion of Manantali Dam, the High Commissariat has not been able to exert effective control over the dam. Until recently, it has been operated by the Manantali Task Force. The need to complete the building of the auxiliary works (the right bank dike built by Razel Corporation, for example) hampered operation of this lower dam. This situation has been corrected since control was transferred to the OMVS dam authorities.

The eight-day limit on flow forecasts at Bakel is not long enough for satisfactory water control. The forecasting time should be increased to at least two weeks to allow for the efficient programming of artificial floods. This will require instrumentation of the part of the basin located in Guinea.

The most important issue is the double artificial floods resulting from the lack of synchronization between the discharges from the non-regulated tributaries and the releases at Manantali. Double floods devastate flood-recession crops in the Middle Valley. To solve this problem, the flow of the tributaries upstream from the Manantali Dam, in Guinean territory, must be through the sharing of information on rainfall and flow.

The state-discharge relations at the river gauges are not correctly established. This standardization issue is essentially due to the tributary-induced losses and the lack of accurate data on the behavior of subterranean waters. The Subterranean Waters Development Project, which will establish a minimal piezometric network and design a hydraulic master plan, will need to be revived.

The OMVS plans to study the tributaries' behavior, which should lead to the building of monitoring works at the river's junctions. This program must aim, beyond the objectives of monitoring the river's characteristics at integrated water management of the tributaries for the benefit of fishing and irrigation and other uses. Global management, as it is being practiced, does not take into account local peculiarities or projected actions such as the refilling of the Ndiael or the Cayar canals.

The management of the flows in Bakel is made difficult by the lack of correlation between water flow and height for certain stations. As a result, some basins are under watered while others are over watered. The first successful artificial floods were not achieved until 1992. This situation deserves an analysis of its effects on developmental and environmental activities. After the turbines are installed, the artificial flooding activities should be studied again. Hydroelectric power production will maintain constant low water flow level, but the river's natural floods will stop because of the need to ensure that water levels in Manantali Lake allow for maximum electric power output.

Hydrological parameters in 1992 at Bakel, according to OMVS records, were as follows:

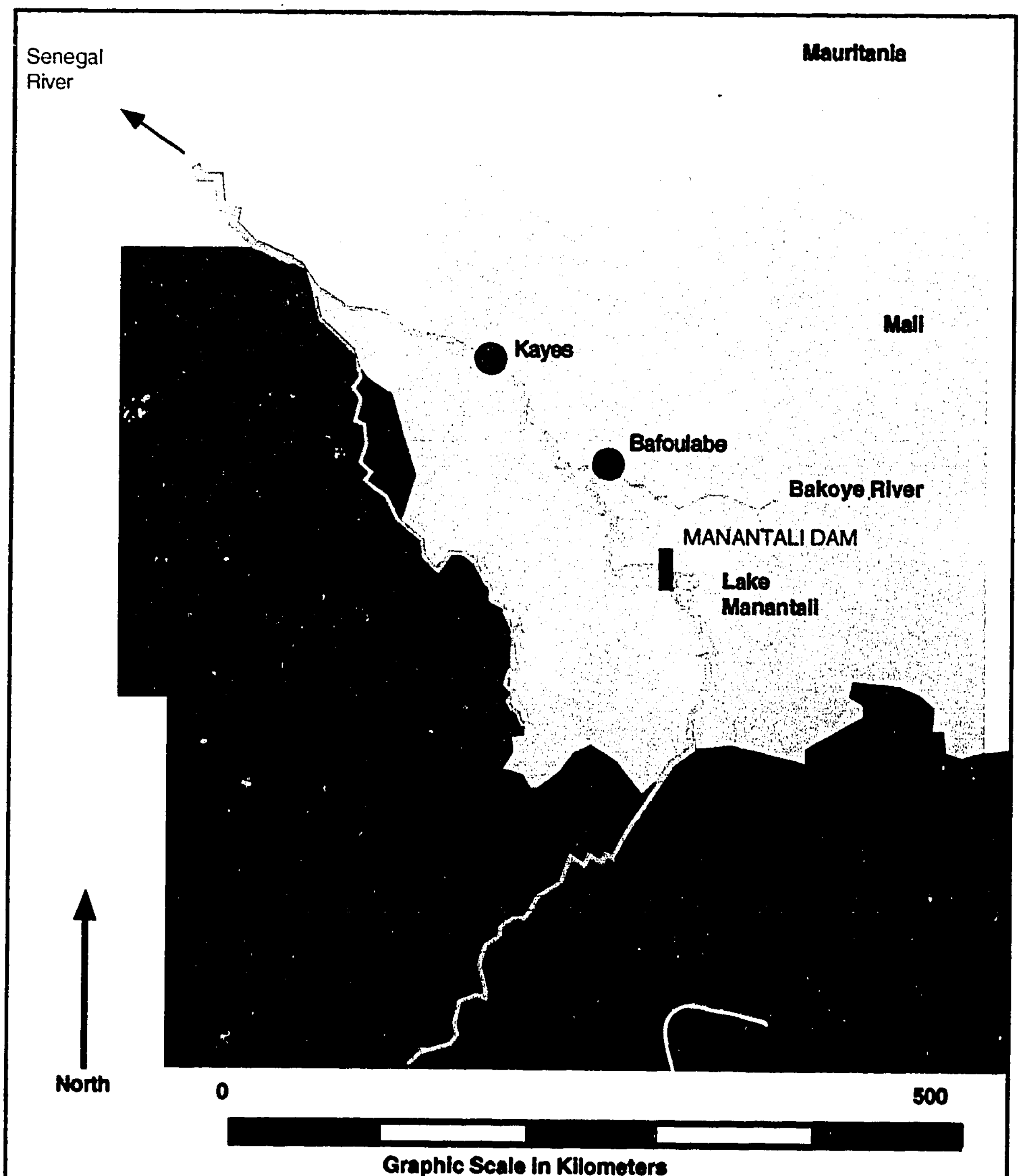


Figure 31: Upper Part of Senegal River Basin Upstream of Bakel

- Daily minimum: 80.7 cubic meters per second on January 1
- Daily maximum: 2,380 cubic meters per second on September 3
- Average yearly flow: 397 cubic meters per second

These parameters should be compared to those in 1986, before the dams, for an idea about the natural character of the river:

- Daily minimum: 0.11 cubic meters per second on June 18
- Daily maximum: 2,800 cubic meters per second on September 8
- Average yearly flow: 343 cubic meters per second

The dry season flows (daily minimum) were higher in 1992, but the level was still limited compared to the expected requirements for sailing and electric power production. The daily maximum was less in 1992 than it was in 1986. This phenomenon reflects the leveling of the floods coming from the Bafing. There is more water in the river when it is regulated than when it operates naturally.

Electric power production suppresses artificial floods in order to maximize power output. The Manantali Group study suggests that artificial floods allowing for the cultivation of 75,000 hectares would mean that the electric power output would be limited to 450 gigawatts/year, which is beneath OMVS objectives and would no longer be profitable. In contrast, the study conducted by USAID in 1[illegible] has proven that it is possible to combine the floods from the non-monitored tributaries (the Falémé and Baoulé-Bakoye rivers) with water releases in order to generate floods able to ensure a reasonable level of flood-recession crops. This combination preserves the valley's ecological balance without compromising electric power output. Within such a context, suppressing the floods hardly seems justified.

Reducing the flood peaks in order to maintain the water volume needed for the electric power production will have an effect on the hydrology of the areas downstream from Manantali Dam:

- Reducing the submersion of some basins and the permanent drying of some others that are slightly elevated in the alluvial plain of the Middle and Lower valleys. The hydrology of basins without dikes will be strongly disturbed.

- Reducing the refilling of alluvial stretches of water that normally supply the river's low-water flow level, especially in the Middle and Lower valleys. This aspect of the problem may be difficult to assess because of a lack of data on the subterranean water transfers from the alluvial nappes and vice versa. The USAID-funded Subterranean Waters Development Project to study the behavior of the nappes gave insufficient results. Its objective of setting up a minimum piezometric monitoring network could not be implemented at the end of the project in 1990. However, OMVS efforts to revive this project in collaboration with the relevant agencies of the member States must be encouraged.

- The decreased flow into tributaries such as the Koundi, Doué, and to a lesser extent the Gorgol rivers. The filling up of these tributaries may become more difficult and, thus, could impede the water supply in the village-irrigated perimeters connected to these tributaries.

- Disturbances may occur in fulfilling irrigation water needs assessed in accordance with the predicted development pace. The areas actually farmed fall short of the forecasts of 375,000 hectares, which is the basis on which the water volume calculations were made.

- During the current transitional period, it is planned to ensure a sustained low-water level of 200 cubic meters per second, which, if navigational needs are taken into account, should be raised to 300 cubic meters per second. It should be noted that the need to reduce useless water losses led the OMVS to envision the systematic monitoring of these flows from the river by the building of regulating and closing structures. These constructions will certainly contribute to reducing the flows' intakes toward the depressions, thus noticeably modifying their hydrological behavior.

THE CONCEPTS OF AN INTEGRATED MANAGEMENT

Even though the OMVS plays a major role in coordinating the basin's development, promoting integrated development by the member states still poses problems and restrains the efficiency of the OMVS.

Development objectives would benefit from a strategy based on:

- The potential resources, the proper modes of exploitation, and the need for resource preservation

- The conceptual system of articulation of the key factors of development and environment

- The appropriate planning instruments for each system component

Natural Resources Planning Strategy

The abandonment of sectorial planning (e.g., power, irrigation, and navigation) imposes itself as the prerequisite for integrated planning that takes into account all the potential functions of space and resources. Master plans must be developed on the basis of space or hydrological units and must also take into account historically established activities as well as all the potential resources of the area. This simultaneous exploitation and complementary use of generated resources should, in principle, create a balanced development.

Linkages between Production Systems, Cultural Heritage, and Technology

The improvement of production systems must integrate cultural heritage and agricultural traditions as decisive criteria. This would have avoided the failures of the past two decades of irrigation. Technological choices did not consider the cultural paradigm and the degree of organization of the local communities.

The Conservation of Basic Resources

Development must seek balance with the environment, and also with public health. A development policy that encourages natural and human resources cannot be a lasting one, for it leads inevitably to the disintegration of human societies. In the Senegal River Basin, the disruptive changes introduced by more than three decades of development must be studied. Data were not collected previously for evaluation of past efforts, thus the OMVS needs to seek assistance in establishing continuous monitoring and evaluation of its current efforts, in order to conserve resources through their integrated management.

The hydroelectric component presently being implemented will introduce important changes in the management of the hydraulic resources that influence the OMVS program's success. It is, then, a priority for the OMVS to establish a good working relationship with the national agencies intervening in the basin. This relationship can provide the material and human capacities required to correct the negative development trends in the basin. An essential task for the OMVS would be the coordination and dissemination of all available information among these agencies.

Chapter 13: Health Conditions and Their Relations to Development

This chapter is an extract of findings from Volume 1, emphasizing those health conditions that have been identified as being affected by the dams and irrigation developments in the basin. The links between development projects are explored for each disease, followed by recommendations for integrated and sustainable measures for control of that disease.

BILHARZIA

Impacts of Water Development in the Senegal River Basin on Schistosomiasis

The life cycle and transmission of schistosomiasis depend entirely on water. Therefore, in almost all parts of the world, constructing new dams and extending irrigation have resulted in the increase and extension of schistosomiasis. Similar ecological changes as the result of the construction of Diama and Manantali dams have occurred in parts of the Senegal River Basin especially in the Delta region. In the Delta region, the construction of Diama Dam reduced the intrusion of sea water to the river. This reduced water salinity and provided favorable conditions for the breeding of snail hosts of schistosomiasis.

From Diama Dam in the west to Dagana in the east, the river has been transformed into a relatively stable lake. There is no more flooding or salt water intrusion. This stability has promoted extensive emergent weed growth on both sides of the lake. The main emergent weeds observed in our survey were *Typha* and *Cyperus articulatus*, with lesser growths of *Paspalum, Vossia*, and *Polygonum senegalense*. This dense vegetation is an effective barrier against wind and wave action, and has created ideal snail habitats along the entire lake perimeter. In every village and town along the lake, sites of human water contact create openings in the emergent vegetation zone. Floating weeds served, in many of the sheltered water contact sites, as favorable substrates for the snails.

Because of the lack of a piped water supply in the villages and towns, it is inevitable that people will have frequent and prolonged contact with the lake for many of their domestic and hygienic needs, e.g., washing clothes and utensils, fetching drinking water, and bathing. The lake is also ideal for swimming and playing. The same water contact sites are used by horses, donkeys, sheep, and goats. The lack of sanitation facilities concentrates urinary and fecal contamination in or near the water. The proximity of the snails, people, and livestock in the calm water is ideal for the transmission of the bilharzia parasite to humans and animals.

The two dams have created a similar environment at Lake Guiers, the Lampsar River, and, to a lesser degree, in main canals such as those at Richard-Toll in Senegal and Fass in Mauritania. Where formerly there was significant water fluctuation and varying degrees of salt water intrusion, there are now stable water levels, extensive weed growth, and expanding populations of medically important snails. The expansion of rice and sugar cane cultivation in the Delta is creating more irrigation canals, pools, and drains. Without any investment on weed-growth prevention, these new water bodies will be infested with bilharzia-transmitting snails.

As the result of the dams' extension of irrigation areas and the immigration of populations from other regions to the newly irrigated areas, a population explosion occurred in some areas of the Delta region, such as Richard-Toll, where the population of 3,000 in 1956 had increased to 50,000 in 1994. Some of the immigrants coming from the schistosomiasis infested areas of the south contributed to the introduction of this infection in the Delta region.

In the Middle Valley of the River, the result of snail surveys made by the WASH/OMVS team indicated that, at present, snail-hosts of intestinal schistosomiasis had not infested the Senegal River East of Dagana, the Foum Gleita Scheme on the Gorgol River, nor the rice-growing areas around Podor. This supports earlier field surveys, which have not reported the species anywhere in the middle river basin. The lack of vegetation in the Senegal River East of Dagana is the main reason for the snails' absence in that habitat in and around the canals at Foum Gleita and Podor. Snails found in this area are not good hosts for the local strain of urinary schistosomiasis, but they can transmit animal schistosomiasis. On the other hand, it seems that the most sensitive snail-hosts for urinary schistosomiasis, *Bulinus senegalensis*, will disappear in some low-lying areas that are no longer prone to widespread flooding. But the species is expected to expand in other areas where development projects carve out more laterite depression pools that can hold rain water or rice-related irrigation canals.

In the Upper Valley, the construction of Manantali Dam and the creation of the lake extended the breeding area of the snail hosts of schistosomiasis and increased their numbers. Our surveys encountered, around the lake shore, large numbers of shells of *Biomphalaria pfeifferi*, the snail hosts of intestinal schistosomiasis.

The reason for not finding living snails around the lake may be due to a lowering of the water level of the lake, thus causing stranding and death of the snails. The effect of the dam construction on snails and on schistosomiasis transmission downstream along the Bafing river is not clear. Apparently, depressions connected to the river, which contained water only in the rainy season, were the main transmission sites. Thus, creation of the lake may have resulted in less water in these depressions, and a shorter season of transmission.

MALARIA

The developments in the Senegal River Basin have had mainly negative, but also some positive, effects on the development of malaria.

Positive Effects

- The stabilization of the river water level has prevented the development of malaria mosquito breeding sites in pools on the river banks left behind by the receding water after the traditional annual flood. For the same reason, breeding also no longer takes place in pools dug in the river bed during the dry season for the collection of drinking water.

- The developments in the river basin have contributed to an increase in transport facilities and improved infrastructure. For a substantial part of the population, this has improved access to health facilities, resulting in increased use of malaria treatment that probably has reduced sickness and death caused by malaria.

Negative Effects

- The increase in irrigation activities has increased the availability of breeding sites for malaria and other mosquitos. Irrigation after the end of the wet season, to grow a second crop of rice, prolongs the season of malaria transmission. Irrigation activities also increase the relative humidity of the air. This increase may extend the average lifespan of malaria mosquitos and, therefore, the transmission of malaria.

- In the Delta (downstream of Rosso), malaria transmission was not a problem because of very low rainfall. The introduction of irrigation systems has enabled malaria mosquitos to develop. So far, malaria transmission has remained low, but this may change in the future.

Recommendations

- Given the importance of malaria as a public health problem, more resources should be devoted to providing people with timely and correct treatment by improving the health services. Accurate microscopy is important for the correct handling of treatment setbacks and enables simple, but important epidemiological studies. To improve and maintain the quality of the microscopy, it is essential to provide microscopists with refresher training regularly and to introduce a system of double blind checking of positive and negative slides.

- It is important to establish a system for coordination of research on malaria (and other vector-borne diseases). Researchers should give more priority to studying the epidemiology and control of malaria along the Senegal River. More knowledge may help in the development of locally cost-effective malaria control strategies.

- Valuable information can be obtained by improving the case detection and reporting capacity already existing in Richard-Toll, Podor, and other places. An analysis of the microscopists' data on age and sex distribution of positives (and fever cases) and on the place of origin of the positives would allow for a comparison of the epidemiological situation between villages and may provide an indication on factors that influence malaria transmission. Consistent collection of microscopy data also allows for the monitoring of malaria endemicity.

- Following the trials with insecticide-treated mosquito nets by Carrara and others in 1989-1992 in the Department of Podor, health workers and researchers should give more attention to this very effective malaria control method. On the Mauritanian side of the river, health workers were unaware of the possibility of treating mosquito nets to enhance their protective effect.

- In the area near Podor (but also, for example, in The Gambia), a major operational problem appears to be the treatment of nets with insecticide. People generally do not want to spend their money on insecticide. The health services do not have a budget for the sustained provision of free insecticide to all people living in malaria-prone areas. It should also be studied whether insecticide offers important additional protection in situations where people keep domestic animals close to their own sleeping areas during the night.

MALNUTRITION

The Annual Floods

The disappearance of the natural floods has significantly reduced the production capacities of traditional crops such as sorgho, corn, and niébé beans. The decrease of these foodstuffs in the diet of the valley residents has contributed to the poorness of their food consumption and, thus, their nutritional quality. This contributes to high levels of malnutrition.

Since the dams have been put into operation, the water releases from the Manantali Dam have not been adequate. OMVS should ensure an annual artificial flood of sufficient duration and volume so as to allow the farmers to cultivate cereals as the water level drops in the walo side of the river. The floods will also benefit fishermen.

Integrated Development of the Valley

In the valley's development program, emphasis was laid on agriculture and on the dissemination of a new method of agricultural production. The other elements of the traditional system of production, namely fishing and cattle breeding, have been widely ignored at the planning and implementation stage of this program. The construction of the dams and the extension of intensive agriculture have generally been unfavorable to fishing and cattle breeding. This situation has had negative repercussions on the valley and its population in terms of family incomes and food consumption. In planning the development of future perimeters, it seems necessary to accommodate cattle breeders in terms of water, grazing fields, and passing corridors for the animals.

Water Availability and Inappropriate Food Consumption

The availability of water throughout the year does not ensure the production of enough foodstuffs to fulfill the nutritional needs of families. Even though water is available at any time, important constraints linked to production factors, namely the exorbitant farming costs, account for the fact that globally, the benefits are limited as compared to the resources needed to feed the population correctly. The absence of family benefits is linked to inappropriate food consumption, which, in its turn, is linked to the existing malnutrition.

Priority Given to Rice Cultivation

Senegal and Mauritania's policies favoring rice cultivation in the irrigated perimeters do not ensure appropriate food consumption at the level of the valley's families. The importance given to rice production is due to the predominance of rice in the present diet, which represents an impoverishment of the nutritional quality of family food consumption compared to that of the past. Existing malnutrition is partially due to the predominance of rice in the family diet. The river basin states and their agriculture management agencies should promote the diversification of the crops exploited in the irrigated perimeters to include other cereals. The communities' nutritional situation has been studied in correlation with the development strategies applied in the Senegal River Basin. Observed changes were related to the river's annual floods, the denial of agriculture as a priority, the rice policy, and water quality.

Evolution in Nutrition

A continuous monitoring system will have to be put into place to follow the evolution of food availability at the family level and the nutritional state of the valley's population. Study sites in each country and region should be identified. Research teams from the agricultural and public health sector in each country should analyze household incomes and expenses at different times of the year.

Water Quality in the River and Canals

OMVS hopes to supply the valley's population with a definite quantity of water, but water quality control has not been defined as a priority by the OMVS or the river basin states. River and canal waters contain agricultural chemical product waste, human and animal excrement, and industrial products. These pollutants constitute a danger for humans, animals, and fishing. It is recommended that river and canal water quality control systems be developed to ensure that pollution levels do not exceed acceptable limits. It is also important to improve irrigation draining systems to ensure that the polluting elements do not go back into the river and canal waters.

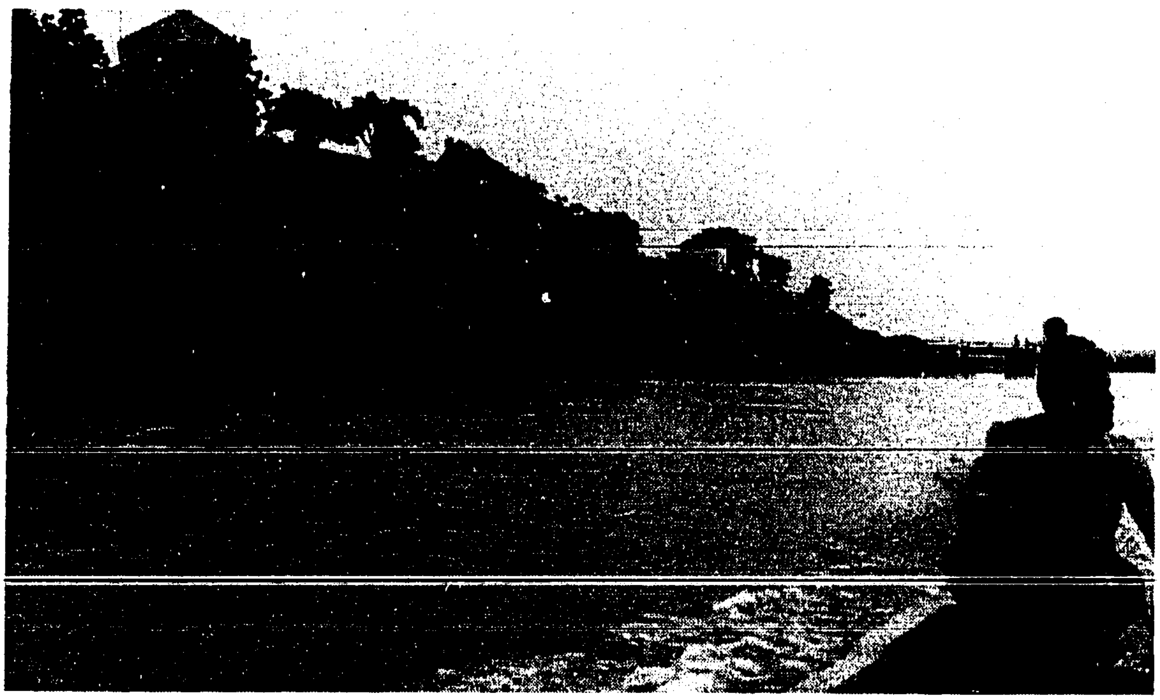
DIARRHEAL DISEASES

Although villages along the edge of the river in the Middle Valley have experienced a reduction in the previously seasonal epidemics of diarrheal diseases, all of the towns and larger communities in the basin are at high risk of increased diarrheal disease transmission because of severely inadequate supplies of safe drinking water, and for the lack of sewage systems (**Figure 32**). The situation is serious in the area around Richard-Toll where cholera epidemics could occur at any time. While treatment of diarrheal diseases at primary health centers with oral rehydration salts (ORS) can dramatically reduce the death rates among children and should be actively promoted through the health services, major improvements i[illegible]r supply systems and sanitation are needed to reduce the high and rising rates of diarrheal [illegible]s.

Figure 32: Middle Valley of Senegal River. In the Middle Valley, Kaedi *(a)* and Bakel *(b)* have adequate quantities of water in the dry season now that the river is regulated, but the quality is severely degraded due to domestic and agricultural pollution.

Figure 32: Vallée intermédiaire de fleuve Sénégal. Dans la vallée intermédiaire, Kaedi *(a)* et Bakel *(b)* ont des quantités suffisantes d'eau pendant la saison sèche maintenant que le fleuve est régulé mais la qualité a beaucoup souffert à cause de la pollution agricole et ménagère.

(a)



photos: Jobin

(b)

Although existing systems of water supply and sanitation are inadequate, and government agencies have not been able to cope with the increased needs due to population growth around the agri-business projects in the Lower Valley, these projects continue to expand. The large projects should take the major responsibility for the excessive sanitation problems caused by their rapidly growing labor forces.

We therefore recommend that the OMVS can play two very important roles in reducing diarrheal diseases:

- The OMVS should have a detailed study conducted on the needs for water supply and sanitation in the basin. The study should include feasibility studies of well-defined projects for the entire region, projected to 2028. Appropriate solutions to meet these needs should be based on natural constraints related to soils and the underground aquifer. Requirements for these studies are detailed in an annex to this report. These studies should compile a catalogue of projects ready to be developed as soon as financing can be obtained.

- The OMVS should monitor the reserves of water in the Senegal River to ensure sufficient volumes to supply urban and rural communities that do not have adequate supplies of their own. This role also includes the surveillance and protection of water quality in the river and its affluents and branches. The OMVS should adopt drinking water quality standards for all waters in the basin. Agricultural runoff and pollution should also be studied throughout the basin.

GUINEA WORM DISEASE, ONCHOCERCIASIS, AND RIFT VALLEY FEVER

Guinea Worm Disease

In the absence of accurate baseline data, the relationship between the occurrence of guinea worm disease and developments in the basin can only be speculative.

Possible Positive Effects

- Stabilization in the river water level may have reduced guinea worm disease to some extent by preventing people from digging pools in the dry river bed for the collection of drinking water during the dry season. Before the operation of the dams, transmission of the disease in the upper part of the Middle Valley probably also took place in such pools.

- Irrigation canals in Foum Gleita and the stabilized river water level of the Senegal River now provide a reliable source of drinking water during the dry season. This may prevent people from collecting contaminated water at pools away from the river bed during the dry season.

Recommendations for Control

The guinea worm disease eradication programs in Senegal, Mauritania, and Mali seem to have made significant progress. Specific recommendations to the OMVS are therefore not needed.

Onchocerciasis

The activities of the Onchocerciasis Control Program prevent an independent analysis of the effects of the dams on the blackfly populations and on the risk of infection with onchocerciasis (**Figure 33**). Some suggestions, however, can be made.

Positive Effects

- Artificial fluctuations in water level, especially abrupt cuts in the water flow of the Bafing River between Manantali Dam and the confluence with the Bakoye River near Mahina/Bafoulabe, may have reduced the breeding of blackflies by stranding the larvae attached to rocks and branches submerged in the water.

- Blackflies have been totally eliminated from the lake area.

Negative Effects

- A continuation of the water flow during the dry season may have enabled some blackflies to extend their breeding season to the end of the dry season. The Bafing River used to be dry between February and July.

Recommendations

- Turbines in the dam will be installed for the generation of electricity. The generation of electricity necessitates a relatively constant flow of water that may result in year-round breeding places in the Bafing River. A study should be carried out on the feasibility and effectiveness of careful river flow manipulation at the dam to prevent blackfly breeding. The effects should be evaluated at various distances from the dam; for example, in the Manantali/Bamafele area, near Bafoulabe (below the confluence with the Bakoye River) and near Kayes.

- A gravity-based irrigation system will be built in the area below the dam. The canals should be designed so that blackfly breeding will not be possible; for example, by preventing spillways, covering certain places with screening, or interrupting the water flow completely for a day or longer.

Rift Valley Fever

Because accurate data about the rift valley fever epidemic in Rosso are missing, the relationship between the developments in the Senegal River Basin and the outbreaks of the fever are hypothetical.

Figure 33: Blindness from bite of blackflies. Boy leading a man affected by River Blindness will no longer be a common sight in Mali, due to 20 year program of the Onchocerciasis Control Program.

Figure 33: Cécité imputable à la piqûre de la mouche noire. Un garçon qui conduit un homme frappé de la cécité des rivières ne sera plus monnaie courante grâce au programme de 20 ans de lutte contre l'onchocercose.

photo: Jamnback

Positive Effect

- The construction of protective dikes around Rosso may prevent future flooding near the town.

Possible Negative Effects

- In August 1987, the Diama Dam reached its highest level. The lack of dikes caused flooding near Rosso. Mosquitos may have bred in large numbers in these flooded areas, and thus provided favorable conditions for the transmission of rift valley fever.

- Development activities helped the population in Rosso to increase considerably. A drainage and sewage disposal system for this increasing population was not introduced, however. During the rainy season, stagnant water in polluted pools is everywhere. These pools may provide suitable breeding conditions to *Culex* mosquitos.

Recommendations for Prevention and Control of Epidemics

An epidemiological study should be carried out to determine what caused the epidemic of rift valley fever in Mauritania in 1987. The findings should be used to design an early warning system for the prevention of future epidemics. An essential component of an early warning system is already in place. The Pasteur Institute in Dakar is monitoring rift valley fever transmission in animals in Senegal and Mauritania. Epidemics affecting humans are normally preceded by increased transmission and abortions in animals.

Unless the importance can be demonstrated of the date of Tabaski coinciding with the beginning of the rainy season and an onset of the fever, then it is unlikely that there will be an outbreak during this century. Tabaski will not again take place during the beginning of the rainy season until early in the next century. If an epidemic is expected, special measures such as vaccination of all sheep brought to places at risk and measures to control mosquitos could be taken after consultation of experts in RVF epidemiology and control.

Chapter 14: OMVS Management of Health Within Development

The position of the OMVS as the pivotal actor in the integrated development of the Senegal River Basin requires that the OMVS develop the capacity to manage and monitor water resources and development interventions. This should be done in conjunction with national institutions to mitigate health problems and ensure the health and nutritional well-being of the Senegal River Basin population. The OMVS portfolio has far-reaching effects, and each of its activities has the potential for affecting the health status of the population in positive ways. Improving health status should be considered an important development objective, and strategies for bringing this about should be actively sought out and implemented.

Our 1994 study identified several important and sustainable measures that the OMVS could take to improve health in the basin. These included coordination of activities by national Ministries of Health, as well as fluctuations in water levels at Manantali and Diama dams and other modifications in water-management and irrigation techniques. These operational measures will be much more cost-effective than unilateral actions taken by national Ministries of Health. Because of its unique and central position in the Senegal River Basin, we have recommended a new organizational emphasis for the OMVS, as well as specific conventional health measures to be taken against the major water-associated diseases. These recommended activities conform to the original objectives of the OMVS for integrated development.

The current organization and coordination of health services with development policies and projects in the basin are not adequate and serious problems are evident. Thus, we recommend the following seven organizational measures.

OMVS COORDINATION ROLE

1. The OMVS should take the lead in coordinating and guiding integrated development of health and water resources in the basin. Improving the health of the population in the river basin will improve agricultural and industrial productivity. Improved productivity will help to create new jobs in the basin. Furthermore, if the basic social infrastructure of water supply, sanitation, and health services is also improved, it may be possible to reverse the current migration out of the basin, and even attract urban dwellers to return. This would further the overall objectives of development that led the member countries to create the OMVS.

OMVS INTEGRATED HEALTH COORDINATION UNIT

2. To coordinate the integrated development of health and water resources, the OMVS should establish an Integrated Health Coordination Unit, headed by a senior public health physician. This OMVS Health Unit should be located in the river basin near Rosso or St. Louis, and should also include personnel from the agriculture and environment sectors.

3. The three member states should formally designate senior health officials to advise their OMVS national representatives on cooperation with the OMVS Health Unit. These officials should come from the National Scientific Working Groups that assisted WASH in preparing this report, and should define their own National Health Action Plans as an initial activity.

4. The first activity of the OMVS Health Unit should be to organize a senior management seminar for OMVS on water-associated diseases and development. The World Health Organization could assist in the seminar because it has recently organized similar seminars through a UN Panel called PEEM, both at Akosombo Dam on Lake Volta, and in Zimbabwe. PEEM is based at the World Health Organization's offices in Geneva, Switzerland, and has offered its assistance to OMVS.

5. The second activity of the Health Unit should be to develop an Annual Integrated Health Program, starting with the recommendations from this report. The Annual Program should be developed by March or April each year in order to guide the Consultative Committee on Common Works of the OMVS, which is meets each May.

6. The Ministries of Health in each member state should establish Operational Field Units in each region or district to execute the Annual Integrated Health Program in cooperation with local communities. Their activities should be coordinated through the OMVS communication system recommended, as described below.

OMVS INFORMATION EXCHANGE AND COMMUNICATION SYSTEM

7. An effective communication system needs to be established in the river valley to provide two-way communication between the OMVS and health agents in riverside communities. The objectives of this communication system should be the following:

   - To develop the institutional capacity to monitor health impacts and define intervention strategies, in order to continuously improve the nutrition and health status of the Senegal River Basin population.

   - To develop a strong liaison with national ministries, regional, district health and development agents, researchers and donors, and especially the residents of the basin, for multi-sectoral communication and information exchange.

   - To develop integrated surveillance systems that are directly linked to action for control and prevention of water-related diseases including malnutrition. These surveillance systems should function at the level of the entire river basin because this ecological system is profoundly affected by OMVS water management; at the level of regions and districts for planning of water management strategies for improved production as well as disease control and prevention; and at the community level because many local environmental conditions and habits relate to water-associated diseases and must be dealt with by local communities.

   - To develop an active integrated health monitoring unit as part of an expanded OMVS integrated development monitoring group.

   - To develop an OMVS Information and Water Management Center in the Senegal River Basin region. The newly created OMVS Integrated Health Coordination Unit should be located in the Senegal River Basin region. The OMVS geographic information system and documentation center and OMVS water level monitoring and control center should be in this Senegal River Basin location. This relocation will facilitate exchange of information among monitoring groups and decision-makers in water management.

- To improve the information flows and intersectoral cooperation concerning development in the Senegal River Basin with regional and district level institutions.

- To develop integrated surveillance systems that are directly linked to action for control and prevention.

- To set up a mobile Information Exchange and Communication System along the Senegal River for systematic, direct communication with regional integrated development committees within each ecological sub-region. A practical Information Exchange and Communication System, which would overcome present problems with overland travel in the rainy season, could be based on river boats that would regularly call at the regional capitals along the river and would maintain communication links with the OMVS Health Unit and with OMVS in Dakar. These boats could be equipped with diagnostic laboratories and linked by local transport systems for reaching remote communities.

- The OMVS should work with regional and district level health systems to establish Operational Field Units and to develop innovative community mobilization. They should also develop health education strategies concerning water and sanitation hygiene and control of vector-borne diseases, which could be used by primary health care workers and school teachers.

- OMVS should support health facilities by providing electricity on a priority basis to hospitals and maternity units.

- OMVS should work with the public health systems in the three countries to improve data validity on the disease situation.

The challenge for the OMVS and national public health systems is to develop an integrated health information system that will have a high degree of user responsiveness, i.e., will be used by people empowered to make decisions and take actions and will thus produce results. The information system should reach to the level of OMVS water management, affecting the entire Senegal River Basin, including the various sectorial programs related to development activities in the Basin. At the same time it should reach out to local communities that have specific environmental conditions and health concerns.

RAPID OMVS COORDINATION FOR DISEASE CONTROL

Timeliness of data collection, communication of the situation, and response are necessary for disease surveillance, prevention, and control. Because the OMVS is an umbrella authority reaching across national boundaries, it is in an excellent position to take an active role in coordinating information flow among the development sectors and interest groups of the three countries and for monitoring and instigating interventions for improving health and nutrition in the entire Senegal Basin.

Chapter 15: Dam Operations, Irrigation Practices, and Navigation

Our 1994 study included extensive exploration of management and operational practices of OMVS facilities, as well as evaluation of agricultural policies and practices related to irrigated crops. This information was then compared with data on the major water-related diseases to explore ways of improving health through integrated operation of the dams and irrigation systems. These methods can be used by OMVS to further the objective of integrated health and water resource development.

MANANTALI RESERVOIR

Recent experience with rapid drops in water level in Manantali Reservoir, as part of a dike repair project, has indicated an important potential method for snail control in the reservoir. Vertical recession rates of three centimeters per day stranded most of the bilharzia snails on the shore of the reservoir during the months preceding our field survey. Studies on hydroelectric reservoirs in Puerto Rico suggested that rates of one to two centimeters per day would be sufficient; thus, it may be possible to achieve snail control in Manantali Reservoir with even lower rates of recession (**Figure 34**).

Although such engineering measures against bilharzia must be repeated more than once a year, they can probably be integrated into the overall water management programs through careful analyses and operational field studies without compromising power and agricultural requirements. Then, with the addition of other public health measures, an integrated attack on bilharzia transmission could be mounted. In addition to developing the details for this operation at Manantali Reservoir, analyses of the design and operation of Foum Gleita Reservoir, where the bilharzia snails have been unable to establish themselves, would give additional information on engineering measures and design features needed to control the snails.

Together, the information from Manantali Reservoir and Foum Gleita Reservoir should make it possible to begin preliminary operational trials on Diama Reservoir where the greatest problems with bilharzia were found. In this case, a careful study of seasonal agricultural requirements for the irrigation systems around Diama Reservoir must be conducted before the operational trials begin. It should then be possible to specify the months in the year when agricultural needs for water are minimal, and short, temporary drops in the water level of Diama Reservoir can be used for snail control.

GUIDANCE FROM UNITED NATIONS PANEL PEEM

The ecological and health problems in the Senegal River Basin have been seen in other river basins. Many other tropical countries are concerned with health opportunities and problems related to river development. Therefore, a UN agency known as PEEM (a panel on environmental management of disease vectors in water resource projects) is willing to assist OMVS in operational field studies of water-level manipulations in the dams in order to control the snails, mosquitos, and blackflies that transmit water-associated diseases in the basin.

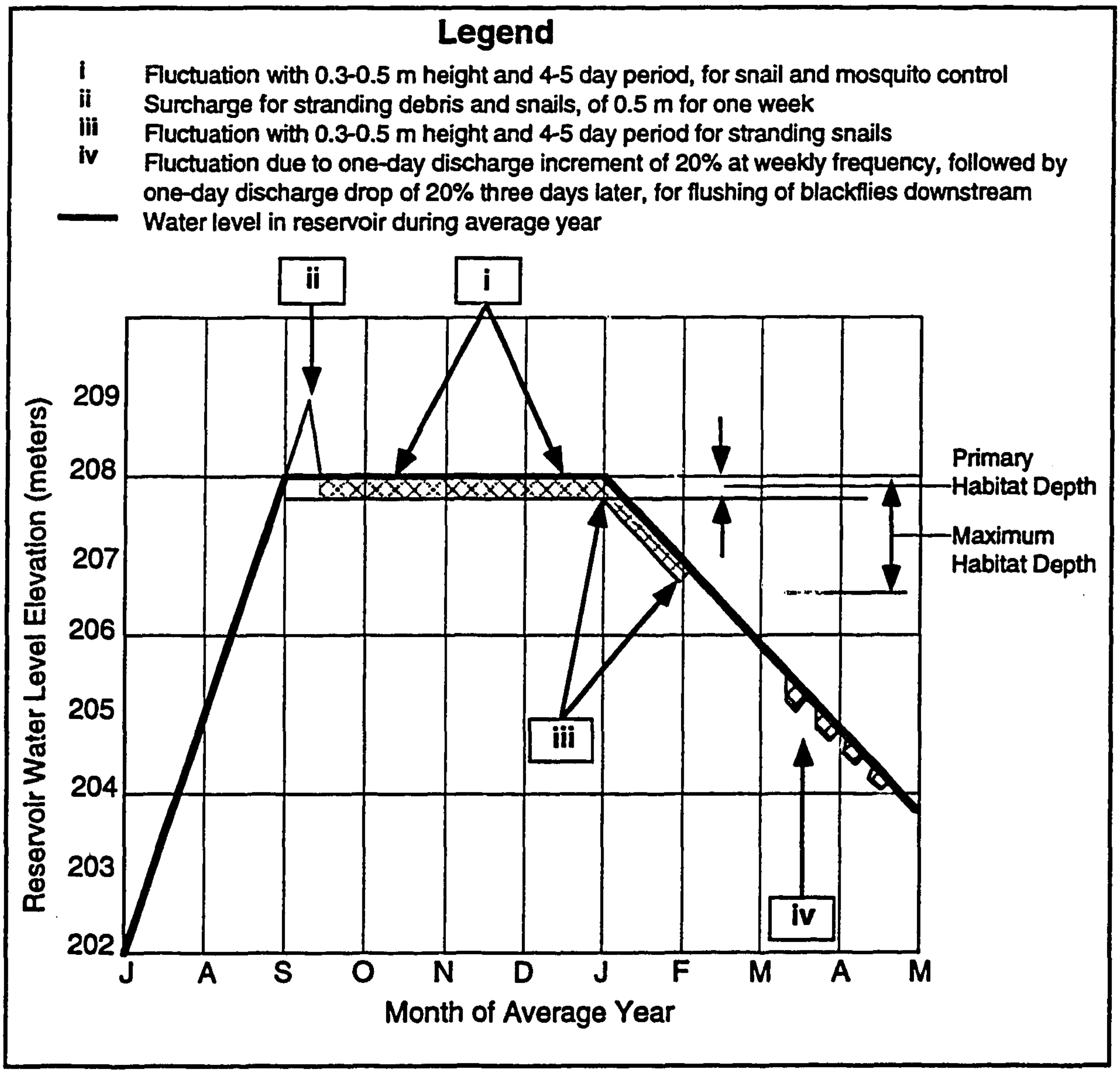


Figure 34. Possible Fluctuations in Reservoir Water Level

We recommend that OMVS accept the offer of this UN agency and develop operational field studies during the transition period before electricity is generated at Manantali Dam. This gives OMVS an unusual opportunity to test a variety of strategies for water-level manipulation. At the completion of the UN-managed study, it should be possible to develop guidelines for control of these disease vectors without interfering with the principal purposes of the dams. The UN proposal should include evaluation of the ecological effects of small manipulations in water level in Diama and Manantali dams, and a thorough study to determine why current operation of Foum Gleita Dam has caused the elimination of snails and bilharzia around the reservoir and in the irrigation system.

FOUM GLEITA RESERVOIR AND IRRIGATION SYSTEM

Although there was considerable transmission of urinary bilharzia in the Gorgol River Basin before construction of the Foum Gleita Reservoir and Irrigation System, our 1994 survey determined that urinary bilharzia had almost disappeared, and that the more severe intestinal bilharzia had not established itself. This was in marked contrast to the two other reservoirs in the basin where intestinal bilharzia had been introduced immediately after construction of Diama and Manantali dams. The reasons for the improved conditions at Foum Gleita seemed to be the large fluctuations in water level in the reservoir and the flat shorelines, which would cause frequent stranding and death of the bilharzia snails, and also the good control of weeds in the irrigation canals (**Figure 35**). Weeds are needed by the snails for protection and food. These two factors should be more carefully investigated, perhaps by the National Center for Hygiene in Nouakchott, to thus provide additional information for the design and operation of water resource projects in the basin.

INVESTIGATE IRRIGATION SYSTEM OF LAKE RKIZ

Cursory inspection of Lake Rkiz and the canals that supply it with water indicated that limited water use owing to a system of recession agriculture in this area may have impeded snail and mosquito populations from developing, although they were found nearby in other irrigated fields, in the Senegal River, and in the canals. Because of these health advantages, this kind of agriculture should be investigated for wider use in the basin.

PROMOTE USE OF CENTER-PIVOT IRRIGATION FOR SUGAR

Around the northern end of Lake Guiers, sugar cane and possibly other crops were being irrigated by modern center-pivot irrigation systems, as opposed to the traditional gravity distribution systems being used around Richard-Toll. These overhead sprinklers considerably reduce snail habitats and human contact with water, and should be investigated for their overall health impact. If they can reduce the transmission of intestinal bilharzia, cholera, and other water-associated diseases, their use should be promoted.

REDUCE EMPHASIS ON DOUBLE-CROPPING OF RICE

Because it provides more habitats for malaria mosquitos and bilharzia snails, and because the labor requirements affect the nutritional status of many farm families, seasonal rotations including other crops with lower water demands should be investigated for their effect on health. In the Mopti region of Mali, the direct relation of rice cultivation and malaria is being investigated by the Mali School of Medicine. Its results should be analyzed for applicability to the Senegal River Basin, and modifications in rice irrigation made accordingly.

NAVIGATION

When plans for improved navigation on the river are further developed, their effect on the increased transmission of disease should be investigated. Boat traffic on the Nile River in Egypt has spread bilharzia upstream to Aswan Dam. If regular river transport is established, travellers can bring in exotic diseases more frequently and from longer distances. On the favorable side, river transport may make access to health facilities easier and cheaper; thus, both aspects should be evaluated.

TRANSITIONAL ARTIFICIAL FLOOD

The favorable health effects of a larger artificial flood during the transition period should be investigated. A larger flood would make cultivation of a larger variety of traditional crops possible, and also restore the productivity of fisheries. Also, wells in villages in the walo zone would not dry up so soon if the aquifer received a larger recharge from the annual flood.

ELECTRIFICATION OF IRRIGATION PERIMETERS

In the configurations being investigated for transmission lines through the basin, provisions for supplying cheap electricity to farmers must not be neglected. Replacement of agricultural losses owing to the elimination of the annual flood will require cheap sources of power for irrigation pumps (**Figure 36**). Without cheap electricity in the Middle Valley, increased malnutrition can be expected, and the populations will be increasingly subject to famine in case of drought.

The same is true for the provision of electricity to health posts and village water supply. Improved health and convenience from cheap electricity would make the basin much more attractive and might stem the migration to Dakar, Nouakchott, and other urban areas.

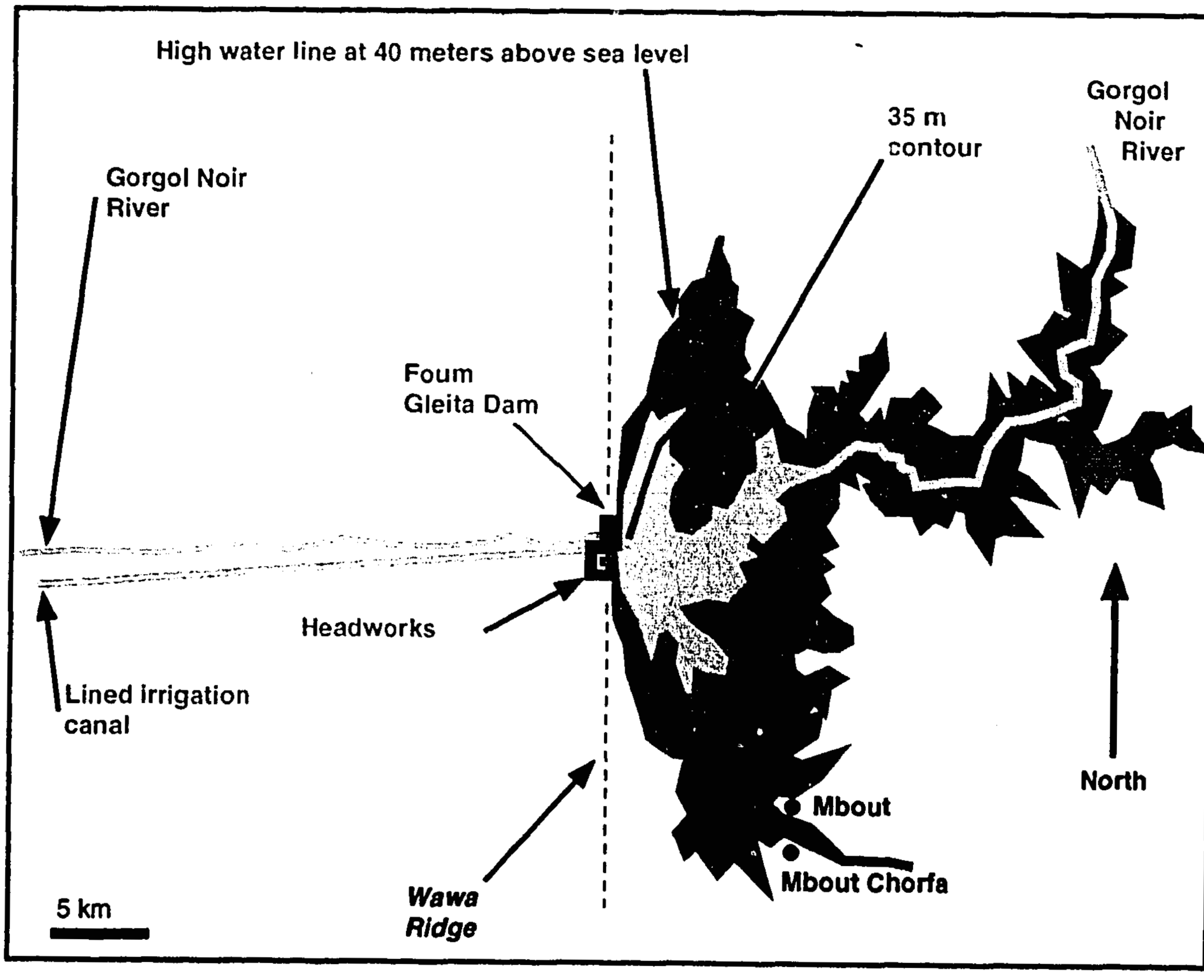


Figure 35: Foum Gleita Reservoir near Mbout in Gorgol Region of Mauritania

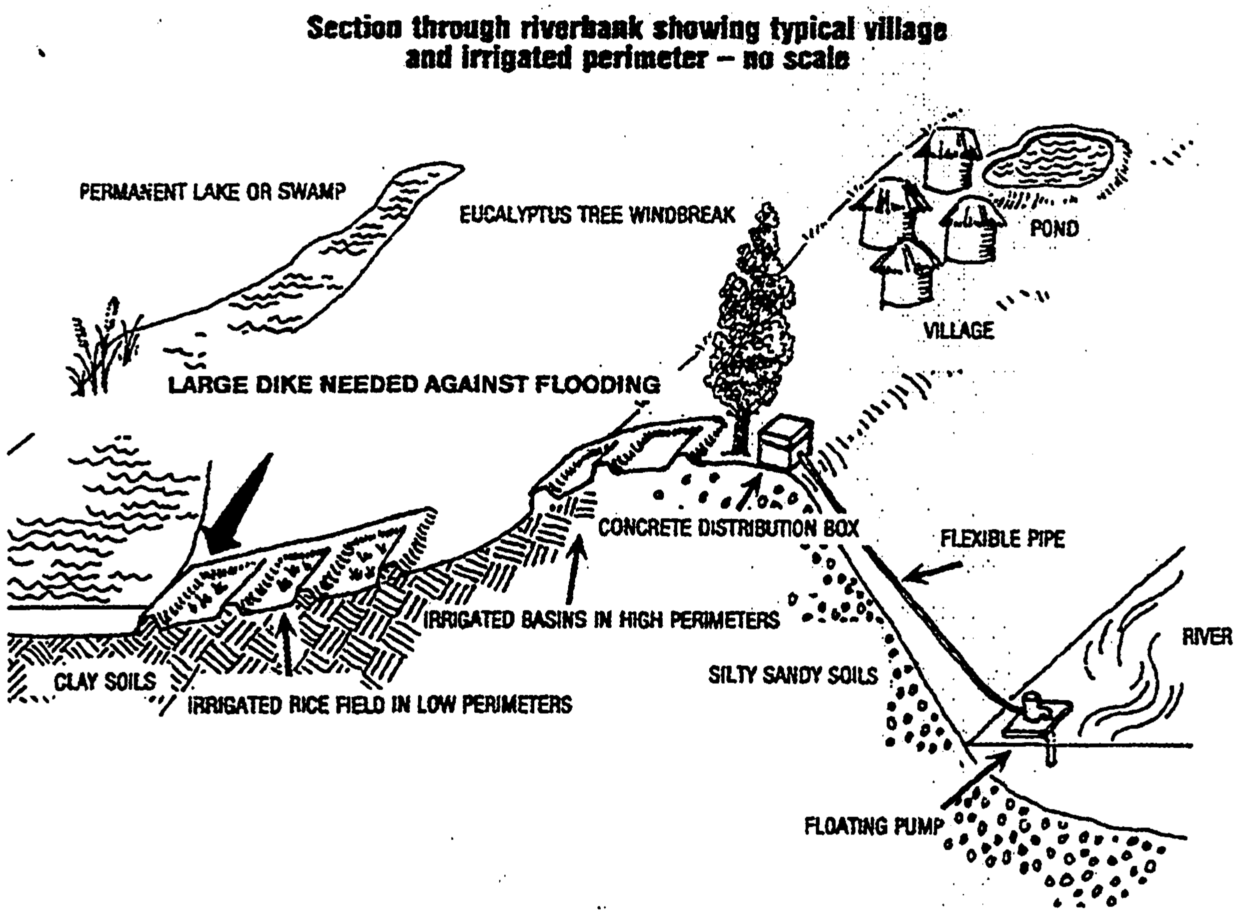


Figure 36. Village Irrigation System in Middle Valley

Chapter 16: Water Supply and Sanitation

Sanitation, sewer networks, and sewage treatment were inadequate and usually completely absent in municipal centers and villages. There were no adequate systems for the collection and disposal of excreta or wastewaters, despite the nature of the soils and the high level of the water table, which posed a considerable risk to public health.

The sewerage network must be extended throughout cities like St. Louis, and developed in the denser portions of other municipalities like Rosso, Mauritania, and Richard-Toll in Senegal. In other parts of these municipalities, individual sanitary facilities are acceptable if they are appropriate for the local nature of the terrain and water table, but the municipalities must then provide a service for the regular emptying of the latrine and septic pits. Every water supply project must also be accompanied by adequate measures for disposal of wastewaters and excreta.

This precarious situation in environmental hygiene explains why diarrheal diseases constituted one of the major causes of infant mortality in the basin. Furthermore, by using ponds and other polluted sources, the populations exposed themselves to parasitic diseases such as bilharzia and guinea worm (**Figure 37**). Improvement of environmental sanitation, especially in the water supply and sanitation sector, is indispensable for the long-term control of diseases associated with water, whether it be diarrhea or bilharzia. Many other health measures can intervene in the short term, or reinforce this sector over the long term, but a Master Plan for Health in the Senegal River Basin should not be developed without a significant water supply and sanitation component.

Clearly, our main conclusion was that the inhabitants of the river valley must have an adequate supply of safe water and adequate sanitation. However, in addition to financial considerations, it is also necessary to evaluate the availability of the natural water resources and to develop the fundamental and important role of general health education.

EXPANSION OF ARTIFICIAL FLOOD TO RECHARGE AQUIFER

The number of village water systems was insufficient and the rural populations obtained water mainly from traditional water sources, ponds, and the river, especially in the Middle Valley. All of these sources were contaminated. Underground water could be further exploited upstream of Dagana if the recharge from the annual flood were restored. However, on both banks downstream from Dagana, the river must serve as the future source for the rapidly expanding towns.

Increases in the duration of the annual flood should be provided. This should be done during the coming 4-6 years of the transition period, and then re-evaluated when energy production begins at Manantali Dam to see if continuing the artificial flood is the best way to provide safe water to these villages.

Figure 37: Scarce water in dry season. During May 1994 residents of villages in western Mali were obliged to use small pools and drying swamps for domestic water.

Figure 37: Pénurie d'eau pendant la saison sèche. En mai 1994, les habitants des villages à l'ouest du Mali ont été obligés d'utiliser de petit points d'eau et des étangs en train de se dessècher pour l'eau du ménage.

photo: Jobin

PROVISION OF PIPED WATER SUPPLY TO HOUSES IN RICHARD-TOLL

Because of the current high transmission rate of bilharzia and the equally dangerous risks from cholera or typhoid fever epidemics or from intoxication episodes from synthetic chemicals or toxic algae, priority must be given to the rapid provision of adequate water supplies and sanitation facilities for Richard-Toll. These systems should be started immediately and should be constructed to handle the population growth estimated for the next 25-50 years.

The agro-industrial organizations developing this area and employing the large labor force should design, finance, and install these systems in the Richard-Toll area. Standards of health and water authorities should be followed carefully, including a design capacity of 100 liters per capita per day for the populations projected into the future. Government agencies should take responsibility for the operation of these systems, and for collection of revenues from the users to maintain a high standard of water quality and quantity in the systems. The alternative feasibility of a payroll deduction for obligatory water connections should be compared with a water consumption charge.

Health education on a large scale will also be required by government agencies, and this effort should be financed by the same sources that provide for operation of the systems.

The municipal system of Richard-Toll should be extended to supply the surrounding villages. In all cases the villages should have safe supplies that provide the same amount of water per capita as what is provided in urban centers, and within a reasonable distance of homes.

RE-USE OF SEWAGE FROM RICHARD-TOLL

Parallel with provision of an adequate and safe water supply to all homes in the Richard-Toll area, a sewer system should be constructed with the same financing arrangements as those for the potable water supply. The sewage collected in this system should be regarded as a resource. This sewer system should be designed to re-use the wastewaters to compensate for nutrient losses in natural fisheries and vegetation. The network of sewers should transport the sewage away from the river toward the djeri, ending in several sewage oxidation ponds where the wastes are stabilized through the action of sunlight. Then the effluent from these ponds should be used to supply fish ponds, and finally to irrigate fields of alfalfa and other crops for livestock.

Such systems have been highly successful in many tropical areas and have a solid ecological value in their ability to recycle water and nutrients in ways simulating natural processes. The use of oxidation ponds avoids the power and equipment requirements of mechanized sewage treatment methods. The ponds can produce effluents that are satisfactory for fish production and for the irrigation of crops not used for human consumption.

RE-USE OF SEWAGE FROM TOWNS IN VALLEY

The same system of gravity sewers leading from riverside towns to the djeri areas away from the river are recommended for all the towns in the valley (**Figure 38**).

SEWERAGE SYSTEM FOR ST. LOUIS

St. Louis and other large cities should also use oxidation ponds, or even simpler systems, for treatment of sewage. All industrial wastes must first be eliminated from the system. All industries should be required to treat and recycle their discharges.

Once this separation of industrial and other toxic waste sources is completed, then the main drainage system for St. Louis should be expanded to cover the entire town. The system should then discharge into a deep ocean outfall. The only treatment required for this system, which contains only surface runoff and sanitary wastes, is a system of bar screens that should be periodically cleaned for trash and debris. Plastic trash and other durable materials, however, must not be discharged into the ocean.

This system can probably operate by gravity, but outlying suburban areas should be connected to it. The other areas may require pumping. Such a simple system, with no toxic wastes and a deep ocean outfall properly screened, will be an asset in restoring fish populations along the coast and will recycle nutrients.

The design for the St. Louis sewer system, as well as that of the other smaller recycling systems for villages along the river, should be further refined by a study for water and sewage in the entire valley, with details of the study contained in an annex of this report.

CAYAR CANAL FOR DAKAR WATER SUPPLY

The large Cayar canal proposal should be reviewed by the OMVS and the Ministry of Health of Senegal with two new considerations in mind: equity for inhabitants of the Senegal River Basin, and potentially serious environmental and health impacts.

The Cayar canal and the proposed pumping stations, treatment plants, and distribution systems will provide a high quality potable water supply system to Dakar and the metropolitan area, with a design figure of 100 liters per capita per day for residential connections. In light of the considerably higher risk of water-associated diseases in the Senegal River Basin, the Cayar canal Project and the plans for urban supply to Dakar should be broadened to include equally good facilities for the communities in the Senegal River Basin, and the same standards of quantity and quality should be used in the design of those systems.

The source of the proposed expansion of the supply for Dakar is Lake Guiers and the Diama Reservoir. Because of the design of the canal and because of the industrial plants along the river near the Taouey canal, which feeds Lake Guiers, a detailed study of potential water quality problems in Lake Guiers, and a study of the potential bilharzia problems in the long open canal is strongly recommended. Without such a study and provisions to eliminate these potential risks, the Cayar Canal Project could be the source of serious new health problems for Dakar and all the populations along the route of the proposed canal.

Figure 38: Towns on bank pollute Senegal River. The Toulde sector of Kaedi is typical of towns which should have their sewage directed to areas far from the river, in order to avoid transmission of diarrheal diseases and bilharzia.

Figure 38: Les villes le long du fleuve Sénégal polluent l'eau. Le secteur de Toulde de Kaedi est un exemple typique des villes qui devraient veiller à ce que leurs eaux usées soient déversées loin du fleuve pour éviter la transmission des maladies diarrhéiques et de la bilharziose.

photo: Jobin

EQUAL DESIGN STANDARDS FOR COMMUNITIES IN THE VALLEY

In the municipal water supplies for communities in the basin, the quantity of water produced was insufficient. The treatment processes in the municipal centers appeared appropriate, but the average consumption of water was significantly below the norm. The peripheral zones of these communities suffered the greatest deficiencies. Provision of a safe supply exceeding 100 liters per capita per day is needed to prevent most diarrheal diseases and to reduce bilharzia and other parasitic diseases. However, many of the municipal residents received only about 10 percent of that amount.

River water, loaded with solid matter especially during the rainy season, should be filtered after sedimentation. The river represents an important source for future municipal supplies. Estimates for water demand by the year 2028 reached 48,000 cubic meters per day for Mauritania and 875,000 cubic meters per day for Senegal, representing almost 4 percent of the ensured river flow from Manantali Dam. The municipal water systems must permit consumption rates approaching 100 liters per person per day, increasing as the population grows.

Chapter 17: Integrated Disease Control

The following lists the major recommendations included in this report for an integrated attack on water-associated diseases:

- The need for OMVS to coordinate the attack
- Several organizational measures by OMVS and the Ministries of Health of the member states to implement the attack
- Operational field studies to develop sustainable measures of water management against mosquitos and aquatic snails
- A basin-wide program of constructing community systems for water supply and sanitation
- A new method of ensuring information flow on health and water management

This chapter also details several specific prevention measures. These specific measures are urgent, but they must be part of an Integrated Master Health Plan to be cost-effective and sustainable. The Master Health Plan should be finalized by the new OMVS Integrated Health Unit.

Although some well-financed research institutions may experiment with a variety of drugs and biocides as control methods, especially related to the bilharzia epidemic around Diama Reservoir, the sustainable programs we recommended for OMVS and member states will minimize the use of chemicals and require careful planning and coordination with the other sectors of agriculture, livestock, and the environment.

DEVELOPING THE COMPONENTS

To provide a sustainable basis for the Master Plan, operational fluctuation techniques for Manantali and Diama dams, which would suppress populations of snails, mosquitos, and blackflies, must be developed first. After these fluctuation techniques are refined and tested, an integrated approach should be developed by all the concerned agencies. The second most important step to initiate is the provision of an adequate water supply and sanitation for the communities along the river, especially those around Richard-Toll. The next step, a broad health education program, should be organized in the schools and through village cooperatives. The educational content should cover bilharzia, diarrheal diseases, nutrition, and malaria, including community action measures such as the weeding of the shoreline of Diama Reservoir.

In the absence of a well-developed Primary Health Care System in most of the basin, some of the following methods will have to be applied from the central or regional offices of the Ministries of Health. The first step for starting direct interventions along the river will be the creation of Operational Field Units in the regional or central offices. These units will be responsible for local interventions. These could be under the Institutes of Hygiene in the three member states, or other health agencies.

BILHARZIA

Because of the introduction and spread of bilharzia in epidemic proportions, this disease should be given a high priority. The following measures should be added to the Operational Techniques and Water Supply and Sanitation Facilities beginning around Diama Reservoir, Lake Guiers, and Lake Rkiz:

- Weed removal along shores of Diama Reservoir within 500 meters of houses, through community action. This activity will eliminate protection for the bilharzia snails, making them susceptible to wave action and to predation by fish. This community activity should be coordinated with programmed fluctuations in the reservoir level by the OMVS dam engineers, removing the weeds when the water level is low. The health education program should promote this community action for weed removal around Diama Reservoir, as well as other environmental and sanitation measures.

- Treatment of infected persons in communities where the prevalence of bilharzia in school children is 20 percent or higher. This should start in Richard-Toll in Senegal and the Trarza Region along the river in Mauritania, and around Manantali Reservoir in Mali. In the Manantali fishing villages, everyone should be treated quickly while the snail populations are low. With supervision from medical personnel, the biologists of the Limnology Unit could do this around Manantali Reservoir while making their periodic surveys of fishery activities. Praziquantel is probably the drug of choice, although it is expensive. Merifonate could be used in areas where only urinary bilharzia is found.

- Use of the simple testing device called *dipstick* to diagnose urinary bilharzia infections in areas where this is the only form of the parasite. These reagent dipsticks are quite inexpensive and simple to use. School teachers should be trained in their use and trained to conduct testing of all their students. Treatment, however, should be supervised by qualified health personnel. The areas where this could be done are Matam, Bakel, Guidimakha, Kayes, and Bafoulabe.

- Use of chemical biocides to kill snails in transmission foci near villages where the environmental measures cannot be used. The biocide to use is Bayluscide, which is applied by simple spraying. It is expensive and should be used sparingly.

MALNUTRITION

The first steps recommended against malnutrition are to:

- Evaluate modification of the national policies favoring rice cultivation in favor of more diversified agriculture.

- Improve the nature of the artificial flood in order to revive the traditional drawdown cropping.

- Institute a periodic nutritional status survey on a five-year frequency, using a carefully designed sample. This is needed to evaluate the true nutritional status of the people along the river, in relation to agricultural development.

DIARRHEAL DISEASES

The most important steps for combatting diarrheal diseases begin with a water supply and sanitation facilities survey for all communities along the river, followed by construction and operation of the new facilities. These measures will also be effective in reducing bilharzia transmission. The health education program should include the importance of using the water supplied to homes for personal hygiene and household cleanliness, and should teach the use of home-made rehydration solutions for children.

MALARIA

In addition to improving malaria diagnostic and treatment facilities in local health units, the use of mosquito nets for sleeping should be promoted, especially in Mauritania where they were seldom seen. Acceptable community programs for treatment of these nets with deltamethrine or other appropriate insecticides should be promoted.