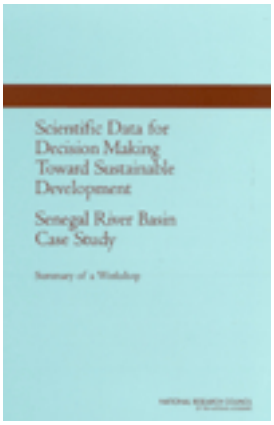

Scientific Data for Decision Making Toward Sustainable Development: Senegal River Basin Case Study -- Summary of a Workshop

Paul F. Uhlir, Director, U.S. National Committee for CODATA, U.S. National Committee for CODATA, National Research Council, Senegal National Committee for CODATA

ISBN: 0-309-55826-3, 68 pages, 6 x 9, (2003)

Scientific Data for Decision Making Toward Sustainable Development

Senegal River Basin Case Study

Summary of a Workshop

Paul F. Uhlir, Director, U.S. National Committee for CODATA

U.S. National Committee for CODATA
Board on International Scientific Organizations
Policy and Global Affairs

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

in cooperation with the
Senegal National Committee for CODATA

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

THE NATIONAL ACADEMIES PRESS • 500 Fifth Street, N.W. • Washington, DC 20001

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This material is based upon work supported by the National Science Foundation under Grant No. INT-0138247. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

International Standard Book Number 0-309-08709-0

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce M. Alberts is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Wm. A. Wulf is president of the National Academy of Engineering.

The **Institute of Medicine** as established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce M. Alberts and Dr. Wm. A. Wulf are chairman and vice chairman, respectively, of the National Research Council.

www.national-academies.org

U.S. NATIONAL COMMITTEE FOR CODATA

Harlan J. Onsrud, University of Maine, *Chair*
William Anderson, praxis101
Peter Arzberger, University of California, San Diego
Robert Chen, Center for International Earth Science Information Network
Richard Chinman, University Corporation for Atmospheric Research
Janet Gomon, National Museum of Natural History
Jan Hopmans, University of California, Davis
Toni Kazic, University of Missouri, Columbia*
Maureen Kelly, Consultant
Gary King, Harvard University
Melanie Loots, University of Illinois*
Goetz Oertel, Association of Universities for Research in Astronomy (retired)
Robert Snyder, Ohio State University
James Sweeney, Consultant

National Research Council Staff

Paul Uhlir, Director, USNC/CODATA
Julie Esanu, Program Officer
Pamela Gamble, Senior Program Assistant

*Rotated off the committee on June 30, 2002.

SENEGAL NATIONAL COMMITTEE FOR CODATA

Committee Officials

Abdoulaye Gaye, *Chair*
El Hadj Malick Diop, Université de Dakar, *Vice President*
Dialo Diop, Université Cheikh Anta Diop, *Secretary General*
Papa Madiaw Seck, Direction de l'Aménagement du Territoire, *Treasurer*

Committee Members

Thierno Gueye, Intellectual Property Rights Consultant
Amadou Ba, Centre National des Recherches Agronomiques
Papa Assane Camara, Institut Sénégalais de Recherches Agricoles
Awa Evelyne Cisse, Délégation des Affaires Scientifiques et Techniques
Balla Moussa Daffe, Université Cheikh Anta Diop
Oumar Talla Diaw, Laboratoire National Recherches Vétérinaires
Lamine Fall, Consultant en Education à distance Dakar
Bouna Gaye, Université Cheikh Anta Diop
Erick Gbodossou, PROMETRA
El Hadj Gueye, Président de l'Ordre des Vétérinaires, Conseiller du Premier Ministre
Mamadou Kanoute, Ministère des Mines, de l'Energie, et d'Hydraulique
Papa Goumbo Lo, Institut des Sciences de la Terre, Université Cheikh Anta Diop
Semou Mar, Consultant en Sciences de l'Education
Mamadou Mbaye, Institut Sénégalais de Recherches Agricoles
Malick Ndiaye, Administrateur Serveur du Gouvernement du Sénégal
Mamadou Ndoye, Chirurgien CHU-HALD
Cheikh Tidiane Sakho, Délégation a l'Informatique

Preface

The U.S. National Committee for CODATA collaborated with the Senegalese National CODATA Committee to convene a Workshop on Scientific Data for Decision Making Toward Sustainable Development: Senegal River Basin Case Study, which was held on March 11-15, 2002, in Dakar, Senegal. This workshop examined, on a multidisciplinary level, data sources and data handling in the West Africa region, using the Senegal River basin (in Senegal, and in the bordering countries of Mali, Mauritania, and Guinea) as a case study, to determine how these scientific and technical data assets are or can be better managed and used in decision making related to sustainable development.

An organizing committee consisting of eight members representative of the expertise and experience required, four from the United States and four from Senegal, planned the workshop. This organizing committee was cochaired by Abdoulaye Gaye, chair of the Senegal National CODATA Committee, and William Jobin of Blue Nile Associates. Areas of expertise that were not covered by this committee were augmented by additional workshop attendees. The organizing committee developed the workshop agenda, prepared for the meeting and related logistics, and selected and invited all the meeting attendees. The U.S. National Committee for CODATA had the responsibility for publishing the workshop summary and disseminating the report.

The workshop included researchers and data managers from the United States, Senegal, and other African countries who have collected, managed, and used data regarding the Senegal River basin. The meeting helped identify local and foreign data resources related to the ecology and environment of the Senegal River system in West Africa, and to the related health and economic activity of the populations. In the Senegal River basin, for example, scientists have been considering issues such as the hydrology and environmental impact of the new dams (Diama and Manantali), biodiversity and ecosystem assessments, protection and use of natural resources, and the monitoring and improvement of the health of the local population. A considerable amount of remote sensing, aerial,

and in-situ data already has been collected and archived for this region, so it provides a robust example of what has been done in one region of the developing world, as well as what might be done in the future.

The workshop provided U.S. federal government and academic data experts and researchers with an inside view of African science and technology data programs and an opportunity to initiate collaboration in various related areas. Prior to the workshop there was a one-day site visit to the Diama Dam on the Senegal River, as well as to the Organisation pour la Mise en Valeur du Fleuve Sénégal (Senegal River Authority) Regional Documentation Center and the Université Gaston Berger, both in Saint-Louis, Senegal. Many of the research activities and training opportunities related to the Senegal River basin are conducted at the university. There was a half-day site visit the following day to the Centre de Suivi Ecologique (Ecological Monitoring Center) in Dakar, which develops, archives, and manages most of the country's ecological and environmental data and information resources.

It is hoped that this workshop contributed to the capabilities for sustainable development in West Africa by identifying and reviewing scientific data activities that could help managers in different sectors, policy makers, and citizens to make better-informed decisions about the Senegal River basin area. The workshop and this resulting publication are intended to foster communication and interaction among a number of interested groups at the local and regional levels. The primary audience includes scientists, data managers, educators, and senior decision makers from the government, nongovernmental organizations, and industry sectors who are working in Senegal and the West African region, as well as their counterparts in the United States who have similar interests in that area. A secondary but also very important audience includes similar categories of individuals in other African nations and in other developing countries outside Africa who are concerned with using scientific data for improved decision making in sustainable development activities, particularly relating to river systems.

This report also is available online via the National Academies Press Web site, and includes hyperlinks where available to organizations and data sources identified during the course of the workshop. Links to individual workshop presentations where available can be found through the U.S. National Committee's Web site at http://www7.nationalacademies.org/usnc-codata/Senegal%20Workshop.html and on the Senegal National Committee's Web site at http://www.codata.sn/16conf.htm.

Paul F. Uhlir
Workshop *Rapporteur*

Acknowledgments

The U.S. National Committee for CODATA and the Senegal National CODATA Committee wish to express their sincere thanks to the many individuals who played significant roles in planning the Workshop on Scientific Data for Decision Making Toward Sustainable Development: Senegal River Basin Case Study. The workshop Organizing Committee was cochaired by Abdoulaye Gaye, chair of the Senegal National Committee for CODATA, and William Jobin, of Blue Nile Associates. Additional members of the Organizing Committee included Oumar Talla Diaw, Laboratoire National de Recherches Vétérinaries; Dialo Diop, Université Cheikh Anta Diop; William Parton, Colorado State University; Madiaw Seck, Direction de l'Aménagement du Territoire; William Sprigg, University of Arizona; and Larry Tieszen, EROS Data Center, U.S. Geological Survey.

The committees would like to thank those individuals from the Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS, or Senegal River Authority) who organized the March 11 site visit to the Diama Dam and the OMVS documentation center in Saint-Louis, including Mbacké Gueye and Alassane Touré, OMVS Regional Documentation Center; Tamsir Ndiaye, OMVS Environmental Observatory; Malang Diatta, Office of Regional Infrastructure; and Mody Seck, OMVS. In addition, the committees extend their thanks to Oumar Gaye, Salta Services International, for arranging the site visit to the Université Gaston Berger de Saint-Louis and the following luncheon. The committees also appreciate the efforts of Moctar Niang, Amadou Dieye, and the staff of the Centre de Suivi Ecologique (Ecological Monitoring Center) for the March 12 site visit to the Centre in Dakar.

The committees would like to thank the following individuals (in order of appearance) who made presentations during the workshop (see Appendix A for the final workshop agenda): His Excellency Fodé Seck, Ambassador, Ministry of Foreign Affairs, African Union and Senegalese Abroad; Donald Clark, U.S. Agency for International Development; William Jobin; Lester Chitsulo, World Health Organization; Amadou Mbaye, Programme Espoir; Larry Tieszen; Amadou Dieye; Wassila Thiaw, National Oceanic and Atmospheric Administration; William Sprigg; T. Tamuka Magadzire, University of California at Santa Barbara; William Parton; Hamdou-Rabby Wane, Centre d'Etudes et de Recherche sur la Population pour le Développement; Alioune Dieng, ISRA; Per Hansen, DHI Water and Environment; Ana Niang, Tropis Cabinet; Mbarack Diop, TROPICA Environmental Consultants; Kristine McElwee, National Ocean Service Pacific Services Center (formerly with Oregon State University); Aaron Wolf, Oregon State University (by teleconference); and Madiodio Niasse, IUCN (by teleconference).

This workshop summary has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, as well as for their attendance at the workshop, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. The study committee would like to thank the following individuals for their participation in the review of this summary report: Dialo Diop, Kristine McElwee, William Sprigg, and Hamdou-Rabby Wane.

Finally, the committees would like to recognize the contributions of the following National Research Council staff: Paul Uhlir, director of International Scientific and Technical Information Programs of the Policy and Global Affairs Division and director of the U.S. National Committee for CODATA, served as workshop *rapporteur*; Julie Esanu helped to organize the workshop and prepare the summary report; and Pamela Gamble organized the logistical arrangements.

Contents

1

Introduction

Rapidly changing technological capabilities for creating, manipulating, disseminating, and using digital scientific and technical (S&T) data are producing many new opportunities and challenges. The opportunities arise primarily in data-intensive research and applications, in the integration of diverse data for new results, and in making vast amounts of factual information available for a broad spectrum of users. The challenges are in effectively managing these data resources for optimal access and use, and for developing rational rules and structures for that process.

At a time when S&T data have never been more important to the progress of science and to the use of these data in support of all types of decision making, CODATA, an interdisciplinary committee of the International Council for Science (ICSU), has worked to improve the effectiveness and impact of such activities. At both the national and international levels CODATA is concerned with all types of quantitative data resulting from experimental measurements or observations in the natural and social sciences and in the engineering disciplines. Particular emphasis is given to data management problems common to different scientific disciplines and to data used outside the field in which they were generated. The general objectives are the improvement of the quality and accessibility of data, as well as the methods by which the data are acquired, managed, analyzed, and evaluated; the facilitation of international cooperation among those collecting, organizing, and using data; and the promotion of an increased awareness in the S&T community of the importance of these activities.

Scientific databases relating to the environment, natural resources, and health on the African continent are, with few exceptions, very difficult to create and manage effectively. Yet the creation of these and other types of databases—and

their subsequent use to produce new information and knowledge for decision makers—is essential to advancing S&T progress in that region and to capacity building for sustainable development in riparian regions.

The Workshop on Scientific Data for Decision Making Toward Sustainable Development: Senegal River Basin Case Study examined some of the scientific databases that have been collected or created about the Senegal River basin (in Senegal, and in the bordering countries of Mali, Mauritania, and Guinea) and used—or not used—for decision making for that region. A multidisciplinary approach was taken, including data and expertise in the areas of ecology, biodiversity, biology, agronomy, hydrology, meteorology, health and medical sciences, geography (geographic information systems or GIS), computer and information sciences, and social sciences.

The project, which was organized jointly by the U.S. and Senegal national committees for CODATA, had several objectives. The most immediate was to focus on important issues relating to the management of scientific data for the sustainable development of the Senegal River area in the West African region. "Sustainable development" has been defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[1] Working toward a sustainable future requires concerted action in three inter-related areas—economic growth and equity, conserving natural resources and the environment, and social development—all areas that were identified as essential yet sometimes conflicting in the development of the Senegal River basin.

The workshop was organized pursuant to the following statement of task in this broader sustainable development context:

1. Identify all types of existing scientific and technical data and information sources relating to the Senegal River basin that have been created or collected by government, academic, and private-sector entities.
2. Examine how these data and information sources have been used for research and for various types of decision making regarding the environment and people in the Senegal River basin area, using specific examples.
3. Identify technical, scientific, management, and policy barriers encountered in both the creation of these databases and in their use for decision making. In identifying these barriers, consider what was done previously and what might be done in the future to overcome them.

In addition to bringing greater attention and understanding to the substantive issues at the interface of data resources and their use in local and regional deci-

[1] World Commission on Environment and Development, 1987. *Our Common Future*. Oxford: Oxford University Press. Also known as "the Brundtland Report."

sion making, the workshop had two other objectives that were focused more on the process itself than on the substantive aspects. The first was to bring U.S. and African experts together, not only to focus on the questions posed in the statement of task but also to develop linkages for future collaborations, both among the participating individuals and between the USNC/CODATA and other African CODATA committees. The other broader objective was to promote U.S.-Senegal and U.S.-African scientific cooperation and to stimulate potential interest in other related initiatives in the area of S&T data activities and capacity building. Toward this end the project was intended to demonstrate to governments, regional organizations, and various decision makers the value of African data work and of cooperation with U.S. governmental and nongovernmental organizations in S&T data projects.

Because this is a summary report of the workshop itself, the report is limited in scope to the presentations and resource documents that were identified during the meeting, and to the information gathered during the site visits to the OMVS Documentation Center in Saint-Louis and to the Ecological Monitoring Center in Dakar on the two days preceding the workshop. Chapter 2 provides some relevant background on the Senegal River basin itself and its regional management organization, as well as a description of the S&T data sources (including links) related to the Senegal River basin that were identified during the meeting. Chapter 3 presents a summary of the main presentations made at the workshop. The concluding Chapter 4 provides a list of key scientific, technical, institutional, and policy issues that were raised in the presentations and panel discussions.

The appendixes to the report provide additional background information, including the workshop agenda, the list of workshop participants, contact information for selected scientific data sources, and a list of acronyms and initialisms used in the report.

2

The Senegal River Basin and Related Data Sources

KEY GEOGRAPHIC AND HYDROLOGICAL FEATURES OF THE SENEGAL RIVER BASIN

The Senegal River is formed by the confluence of two smaller rivers, the Bafing and Bakoye, which occurs near Bafoulabé, Mali, at about 1,083 km from the Atlantic Ocean.[1] After crossing western Mali, the Senegal River constitutes the boundary between Senegal and Mauritania. The Senegal River basin (SRB) occupies a total area of 289,000 km^2. It includes three main regions—the upper basin, valley, and delta—with each region clearly characterized by distinct environmental conditions. Figure 2.1 provides a cartographic depiction of the basin.

As might be expected the flow rate of the river is determined mainly by the rainfall in the upper basin. The high-water season lasts from July to October; the low-water season, with a steady decrease in volume, begins in November and lasts until May or June. The high-water season peaks at the end of August or beginning of September and quickly ends during October.

Another important feature of the Senegal River prior to the construction of its two dams was the inter-annual irregularity in its flow volume. For a long time this inter-annual flood irregularity posed a major problem for the valley, as it decreased the potential for guaranteed agricultural production in this narrow geographic area. The arable land area that could effectively be farmed after the

[1] The description of the Senegal River basin and the OMVS in this section is based on the OMVS report *Pour une gestion durable des ressources naturelles et de l' environnement du bassin du Fleuve Sénégal,* December 2001, OMERIS Communication, Dakar, Senegal.

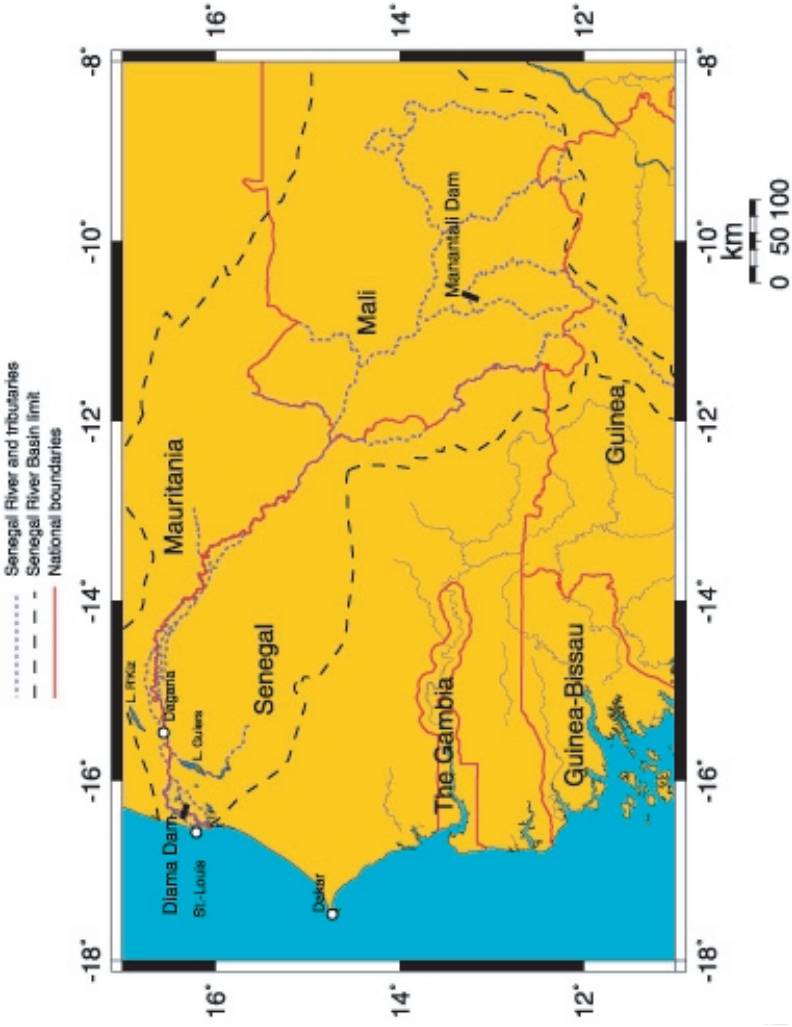

FIGURE 2.1 Senegal River Basin. Source: Kristine McElwee, 2000. Complementing Data: Elements of Decision-Making for Natural Resource Management in the Senegal River Basin. Master's Thesis.

flood could vary between 15,000 ha and 150,000 ha, depending on the magnitude and duration of the flood.

Exceptionally high water levels caused widespread devastation in 1890, 1906, and 1950. Conversely, the years with extremely reduced water flow were also disastrous, since they did not yield a sufficient agricultural production in the valley. Most recently the drought of 1972-1973 was particularly devastating for the populations and the economy of the riparian region. During the low-water discharge period, from November to May or June, no significant rainfall occurred, and the river discharge and that of its tributaries gradually decreased. The particularly low water level during the dry season resulted in a deep intrusion of the ocean's salted waters into the riverbed. During the 1970s a saltwater wedge penetrated more than 200 km upstream of Saint-Louis.

To address the problems associated with the significant inter-annual variability in rainfall and water flow of the Senegal River, three of the four main bordering countries—Mali, Mauritania, and Senegal—entered into a treaty to form the Senegal River Authority, the Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS), and related organizational structures in 1972.[2] The tasks of the OMVS were to attain the goal of food self-sufficiency for the SRB inhabitants; reduce the economic vulnerability of the organization's member states to climatic fluctuations as well as to external factors; accelerate the economic development of member states; conserve ecosystem balance in the subregion, particularly in the basin; and secure and improve the incomes of basin inhabitants.

To accomplish these goals the OMVS was charged with constructing and managing a regional infrastructure consisting of two major dams and related facilities and structures. The Diama Dam was the first to be completed, in 1986, near the mouth of the river at Saint-Louis. The primary goal of this dam was to stop the saltwater intrusion upstream and to make the delta's land suitable for agriculture. The workshop participants were able to visit this dam and to see its operations first hand.

The Manantali Dam was completed a year later as a reservoir dam with multiple purposes, including retention of about 11.3 billion m^3 of water; regularization of river flows to 300 m^3/s at Bakel; irrigated culture development in the downstream valley region; continuous river navigability; and energy production at the power station at the bottom of the dam. The hydroelectric power station, which was completed last year, includes generators that produce 800 GWh/year,

[2] Prior to the organization of the OMVS the four border countries—Guinea, Mali, Mauritania, and Senegal—belonged to the Organisation des Etats Riverians du Fleuve Sénégal (or the Senegal River Riparian States Organization), which managed the river basin. This organization dissolved when Guinea withdrew due to political tensions. The three remaining countries subsequently created the OMVS.

guaranteed 9 out of 10 years, and a 1,500-km transport line network to assure energy delivery to interconnected networks in the three member states.

Still under development is a navigable channel from the mouth of the river over 900 km upstream to enable ships to access landlocked Mali, and the Mauritanian southwest and the Senegalese northeast regions. This part of the project also includes construction of a river port in Saint-Louis and seven smaller ports upstream.

Two private holding companies are now responsible for the management, operation, and maintenance of the dams. The Société de Gestion et d'Exploitation de Diama (SOGED, or the Diama Dam Management Company) and the Société de Gestion de l'Energie de Manantali (SOGEM, or the Manantali Energy Management Company) were created in 1997, and are located in Mauritania and Mali, respectively.

There are several other organizations within OMVS that have various responsibilities regarding the dams. The OMVS Regional Documentation Center is located in Saint-Louis and processes and archives the many documents and data related to the activities of the OMVS, mostly administrative materials. It also provides access to these materials currently only in paper form, and hosts and maintains the OMVS Web site, where a directory of its archived documents is being made available.

In 1998 the OMVS created the Programme d'Attenuation et de Suivi des Impacts sur l'Environnement de l'OMVS (PASIE, or Environment Impact Mitigation and Monitoring program), which conducts environmental impact mitigation and monitoring activities related to the development of the dams. It receives financing from the World Bank and the African Development Bank, as well as France and Canada. PASIE consists of six programs focused on construction impact mitigation and monitoring; appropriations and right of way for transmission lines; reservoir management; environmental health; associated measures; and monitoring, coordination, and communication.

In May 2000 OMVS established the Observatoire de l'Environnement, or Environmental Observatory. The main objective of the observatory is to monitor environmental change in the SRB as part of PASIE's coordination and monitoring program in order to provide required information for measuring environmental impacts of dams and hydraulic development to the OMVS high commissioner, the three member states, and to various OMVS partners to enable decision makers and populations to implement actions that would ease negative impacts on the environment.[3]

---

[3] The workshop participants did not receive a briefing on or visit the Environmental Observatory. For more information about the Observatory and PASIE see OMVS. 2001. *Pour une gestion durable des ressources naturelles et de l' environnement du bassin du Fleuve Sénégal.*

SELECTED SCIENTIFIC DATA SOURCES RELATED TO THE SENEGAL RIVER BASIN

There are many other sources of scientific data relating to the SRB in addition to the OMVS and related organizations that are directly responsible for the oversight, management, and maintenance of the dams and that monitor the environmental issues in the basin. These sources are very diverse, ranging from national and regional sources to international ones, including nongovernmental organizations. Other river systems also provide useful data for comparative analysis. This is not a comprehensive list of data sources for the basin but a pointer to organizations that were identified during the course of the workshop that either collect or disseminate relevant data.[4]

National Data Sources[5]

Senegal

Within the government of Senegal, there are several ministries that focus on environmental, natural resource, and health issues, and therefore conduct work related to the SRB. (Information regarding the relevant ministries can be found on the Senegal government Web site.[6]) These include the Ministère de la Jeunesse, de l'Environnement et de l'Hygiène Publique (Ministry of Youth, Environment, and Public Hygiene), the Ministère des Mines, de l'Energie et de l'Hydraulique (Ministry of Mines, Energy, and Hydrology), the Ministère de la Santé et de la Prévention (Ministry of Health and Prevention), the Ministère de la Pêche (Ministry of Fishing), and the Ministère de l'Agriculture et de l'Elevage (Ministry of Agriculture). The Senegalese government also created the Conseil Supérieur des Ressources Naturelles et de l'Environnement (CONSERE, or the Higher Council for Natural Resources and the Environment) and the Commission Nationale pour le Développement Durable (the National Commission on Sustainable Development) to oversee and coordinate environmental policy.

The Centre de Suivi Ecologique (CSE), or the Ecological Monitoring Center, located in Dakar, is a remote-sensing and GIS data center. It is part of the

---

[4] An alphabetized list of organizations and their contact information, where available, is in Appendix C.

[5] The participants at the workshop did not receive a briefing on all of the national sources of S&T data in the four border countries. This information was culled from workshop presentations and various Web sites, including those of the Senegalese and Mauritanian governments, as well as the "Senegal River Basin Water and Environmental Management Project—Project Brief" (2001, World Bank and UNDP), which can be found at http://www.gefweb.org/Documents/Council_Documents/GEF_C18/Regional_Senegal_River_Basin.pdf.

[6] See the Web site of the Senegalese government at http://www.gouv.sn/ministeres/index.html.

Ministry of Youth, Environment, and Public Hygiene, and also partners with the U.N. Development Programme, the private sector, and local authorities, among others. CSE both collects and provides data for a variety of applications and services for Senegal and the sub-region. For example, to collect data and monitor the environment it uses foreign remote-sensing sources (National Oceanographic and Atmospheric Administration [NOAA]/Advanced Very High Resolution Radiometer [AVHRR], Système Probatoire pour l'Observation de la Terre (SPOT), Landsat Thematic Mapper, and Meteosat), aerial surveys, and field work. CSE also produces a variety of data products and services. These include monitoring plant production using the normalized difference vegetation index (NDVI) derived from NOAA/AVHRR data, estimating rainfall using a Meteosat-based model, evaluating agricultural production using diverse satellite imagery, and monitoring bushfires using NOAA imagery. CSE also provides land-use and land-cover mapping services, low-altitude aerial surveys, and training. Many of the workshop participants visited the CSE and received presentations on CSE data acquisition and environmental-monitoring activities, as well as on applications of GIS on land cover and natural resource management.

Other national organizations in Senegal, both quasi-governmental and private, collect and provide data sources about the SRB. The Société d'Aménagement et d'Exploitation du Delta du Fleuve Sénégal (SAED), or the Society for the Development and Exploitation of the Delta, has the responsibility for the development of the left bank of the Senegal River. The Institut Sénégalais de Recherches Agricoles (ISRA, the Senegal Agricultural Research Institute) carries out agricultural research studies. The Centre de Recherches Océanographiques Dakar-Thiaroye (CRODT), or the Oceanographic Research Center Dakar-Thiaroye, is a research center affiliated with ISRA. The private Institut Pasteur de Dakar focuses on biological research, primarily on infectious diseases, and its applications to public health.

Several universities in Senegal also conduct research in the basin. These include the Université Gaston Berger de Saint-Louis, which works closely with the OMVS in Saint-Louis, and the Université Cheikh Anta Diop, which was formerly the University of Dakar. The Institut de Santé et Développement (Health and Development Institute), which is a cooperative effort of Université Cheikh Anta Diop and Senegal's Ministry of Health, and the Ecole Inter-Etats des Sciences et Medecine Vétérinaries de Dakar (the Interstate School of Science and Veterinary Medicine) are active in biomedical, health, and animal research.

Mauritania

In Mauritania the Conseil National pour l'Environnement et le Développement Durable, or the National Council for the Environment and Sustainable Development, has oversight responsibility for creating a national environmental

strategy. Primary responsibility for the environmental development of the Senegal River rests with the Ministère de la Santé (Ministry of Health) through the Direction de la Planification et la Coopération Sanitaire (Office of Planning and Sanitary Cooperation) and the Ministère du Développement Rural (Ministry of Rural Development) through its Direction Nationale de l'Aménagement Rural (National Office of Rural Exploitation), as well as the Société Nationale de Développement Rural (SONADER, or the National Society for Rural Development). The Ministère de l'Hydraulique et de l'Energie (Ministry of Hydrology and Energy) has oversight for the generation of hydroelectric power and the Manantali Dam. Information about the relevant ministries in Mauritania can be found on the Web site of the Mauritanian government.[7]

Mali

The Ministère de l'Environnement's Direction de la Conservation de la Nature and the Direction du Contrôle des Pollutions et des Nuisances (Ministry of the Environment's Offices of Conservation and of Pollution Control and Nuisances) and the Secrétariat Technique Permanent (Permanent Technical Secretariat) focus on the environmental management in Mali. However, the Ministère de l'Agriculture (Ministry of Agriculture) and the Ministère des Mines, de l'Energie, et de l'Eau (Ministry of Mines, Energy, and Water) have primary responsibility for the management of the Senegal River basin through their Direction Nationale de l'Aménagement et de l'Equipement Rural (National Office of Rural Exploitation and Equipment) and the Direction Nationale de l'Hydraulique et de l'Energie (National Office of Hydrology and Energy), respectively.

Guinea

In the Republic of Guinea the Ministère de l'Equipement (Ministry of Equipment) is responsible for environmental policy through its Direction de l'Environnement (Office of the Environment). Other organizations involved include the Ministère des Ressources Naturelles et de l'Energie (Ministry of Natural Resources and Energy) through the Direction Nationale de la Gestion des Ressources en Eau (National Office of Water Resource Management) and the Direction de la Météorologie (Office of Meteorology), and the Ministère de l'Agriculture, des Eaux et des Forêts (Ministry of Agriculture, Water, and Forests) through its Direction Nationale des Eaux et Forêts (National Office of Water and Forests). The Ministère des Mines, de la Géologie et de l'Environnement (Ministry of Mines, Geology, and the Environment) also plays a role in the environmental management of the upper basin.

---

[7]See the Web site of the Mauritanian government at http://www.mauritania.mr.

United States

A number of U.S. government agencies collect and provide scientific and technical data and information relevant to the Senegal River basin. These include the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the EROS Data Center of the U.S. Geological Survey, the U.S. Department of Agriculture Foreign Agriculture Service, the National Institutes of Health, the U.S. Agency for International Development (USAID), and the Central Intelligence Agency. For example, the International Program at the EROS Data Center applies remote-sensing, GIS, and information delivery systems to meet international and developing country needs. Two of their current projects focus on West Africa. One monitors land use and land cover changes in the Sahel and the other is a prototype pilot project in Senegal looking at carbon sequestration in soil organic matter in Africa. Another example is the Africa Desk at NOAA's Climate Prediction Center. The Africa Desk provides short-term climate monitoring and predictions for Africa, including expert assessments of rainfall outlooks; daily, weekly, monthly, and seasonal analyses; and model forecasts and satellite images. Guinea, Mali, and Senegal are participating countries. Some U.S. federal agencies have field offices in the region; for example, USAID has an office in Dakar. Many agencies have partnered with various organizations within the region, including the CSE.

In addition to these significant federal sources of data, other U.S. organizations and universities conduct research in and/or collect relevant data and information about the SRB. For example, the Institute for Development Anthropology is a nonprofit, nongovernmental organization that has been collecting data about the basin and the impacts of the dams for many years. It has one of the most extensive archives of information about the area. There are also a number of universities that have relevant programs, including, for example, Michigan State University, Colorado State University, Louisiana State University, University of Arizona, and the University of California at Santa Barbara.

Other Countries

Many other countries outside Africa have organizations, both public and private, that conduct research and collect data relevant to the SRB, although the listing here is far from comprehensive. In particular, there are many French organizations that are still very active in the region. The Institut Français de Recherche pour le Développement (IRD, or French Research Institute for Development), formerly known as Orstom, is a long-established research organization funded by the French government; it has branches in Senegal, Guinea, and Mali. Germany also has a presence in the basin with the Deutsche Gesellschaft fur Technische Zusammenarbeit, or GTZ, which is a government organization that

promotes international technical cooperation. Denmark, Canada, and many other countries are also active in the SRB, either through direct support of research organizations or through partnerships with international and nongovernmental organizations.

Regional Data Sources

The Comité Inter-Etats de Lutte contre la Sécheresse au Sahel (CILSS), or the Permanent Interstate Committee for Drought Control in the Sahel, is an organization of nine West African countries: Burkina Faso, Cape Verde, Gambia, Guinea Bissau, Mali, Mauritania, Niger, Senegal, and Chad. The Centre Régional AGRHYMET, or the Regional Center for Training in Agriculture, Hydrology, and Meteorology, is the remote-sensing and training center associated with CILSS. The Institut du Sahel is also part of CILSS and is responsible for the coordination and promotion of scientific and technical research in the Sahelian countries. Other regional organizations include the Economic Community of West African States and the Union Economique et Monétaire Ouest-Africaine (West African Economic and Monetary Union). The African Development Bank has financed a number of projects in the SRB, including PASIE and hydroelectric power generation at Manantali Dam. Another relevant regional organization is EIS-Africa, which is an environmental information management network in Africa. This cooperative program is focused on using GIS tools and applications to promote access to and use of environmental information for decision making.

International Data Sources

Many of the United Nations specialized agencies have a strong presence in the SRB, including the U.N. Development Programme (UNDP), the U.N. Environment Programme (UNEP), the Food and Agricultural Organization, the World Health Organization, and the U.N. Educational, Scientific, and Cultural Organization. All of these agencies are partners with various national and regional organizations in the SRB area and participate in a number of initiatives in the basin. For example, UNEP is a partner with the Senegalese Ministry of Mines, Energy, and Hydrology and DHI Water and Environment (an independent Danish consulting and research organization) in a pilot project that is looking at the environmental impacts of the Diama Dam in the Senegal River delta.

Other international and nongovernmental organizations and projects are active in the region as well. The Global Environment Facility (GEF, or Fonds pour l'Environnement Mondial), which is implemented by the UNDP, UNEP, and the World Bank, has several projects in the basin. One will focus on SRB water and environment management. The objective of this GEF project "is to provide a participatory strategic environmental framework for the . . . sustainable development of the Senegal River basin and to launch a basin-wide cooperative program

for transboundary land-water management" through capacity building, data and knowledge management, transboundary diagnostic analysis and a strategic action program, priority actions through pilot projects, and public participation and awareness.[8] Another organization is the Observatoire du Sahara et du Sahel, which is an independent organization comprising African and European member states, as well as nongovernmental organizations, that promotes cooperation against desertification and poverty in Africa; Senegal, Mali, Mauritania, and Guinea are all members of this organization. ENDA Tiers Monde (or Environment and Development Action in the Third World) is a nonprofit organization promoting environmental development in developing countries and is headquartered in Dakar.

The World Conservation Union (IUCN, previously the International Union for the Conservation of Nature) is also very active in the region. The IUCN is a nongovernmental environmental organization. For example, the IUCN coordinated the stakeholder involvement and participation in the GEF regional project through a series of workshops in Senegal, Mali, Mauritania, and Guinea.

Other River Systems

Within West Africa there are two organizations that provide examples of work being done on other river systems. The Organisation pour la Mise en Valeur du Fleuve Gambie (OMVG) is the Gambia River Authority. This organization, which was established in 1978, is similar to the OMVS, and involves Senegal, Gambia, Guinea Bissau, and Guinea; it is headquartered in Dakar, Senegal. The Niger River also originates in Guinea, and the Autorité du Bassin du Niger (ABN), or the Niger Basin Authority, was created in 1971. Its members include Benin, Burkina Faso, Cameroon, Chad, Ivory Coast, Guinea, Mali, Niger, and Nigeria. The U.S. Tennessee Valley Authority served as a model for the development of the ABN and the OMVG, as well as for the OMVS.

[8]See "Senegal River Basin Water and Environmental Management Project—Project Brief," 2001. World Bank and UNDP. The project brief and its cover memo from Lars Vidaeus, GEF Executive Coordinator, to Ken King, Assistant CEO, GEF Secretariat, on the project and its submission for work program inclusion, dated September 21, 2001, can be found at http://www.gefweb.org/Documents/Council_Documents/GEF_C18/Regional_Senegal_River_Basin.pdf. The workshop participants did not receive a briefing on this project.

3

Summary of Presentations on Scientific Data for Decision Making Toward Sustainable Development in the Senegal River Basin

The participants at the workshop addressed a broad range of issues concerning the human, natural, and constructed environment in the Senegal River basin (SRB), with particular focus on the problems created by the Diama and Manantali dams. They identified and to some extent characterized the many different kinds of data that have either already been collected or that are still needed to support decision making toward sustainable development of the SRB. The presentations covered four broad topical areas.[1] The first three addressed environmental, health, and SRB socioeconomic issues and related data aspects, while the fourth focused on issues concerning data for decision making about dam projects.

ENVIRONMENTAL ISSUES AND RELATED DATA

Natural Resources, Environmental Issues, and Data Requirements[2]

The SRB stretches from the river's source in mountains of Guinea to the coastal and ocean zone at Saint-Louis, Senegal. Nutrients and sediment generated in the headwaters are recycled downstream, driving plant and biotic productivity. The lateral connectivity between river and floodplain also drives river life. The appearance of aquatic weeds, sedimentation at Diama Dam, and health

[1] Selected presentations from the workshop, where available, can be found on the U.S. National Committee for CODATA's Web site at www7.nationalacademies.org/usnc-codata/Senegal%20Workshop.html.

[2] Based on a presentation by Mbarack Diop and Samba Yade, TROPICA, Dakar, Senegal.

problems at Richard Toll upstream from the dam underscore the need for regional understanding of these processes.

As noted in Chapter 2, the annual flood at Bakel has peaked in August and September, coming almost entirely from the upper basin. There has been a dramatic reduction of flow in the last 20 years, however, to less than half the 100-year average of 700 m^3/s. The total mean annual discharge is 21,000 million^3. In the middle valley there are 72 minor floodplain basins of 1,000 ha to 15,000 ha supporting traditional flood-recession agriculture and also serving as fisheries breeding areas. Erratic flows and episodic inundation in the river contributed to a wide diversity of floodplain habitats and species, which enabled a variety of food production systems by middle-valley communities. The high variability of rainfall, however, prevented the sustained use of basin resources. The OMVS, therefore, was created in 1972, proposing 375,000 ha of pumped irrigation, navigation from the ocean to Kayes, 800 GWh/yr electricity 9 years out of 10, flood mitigation, maintenance of flood recession agriculture in transition to irrigated agriculture, and control of saltwater intrusion at Diama.

The OMVS program resulted in construction of the Diama Dam by 1986, the Manantali Dam by 1987, and inauguration of the Manantali hydropower unit and transmission line to Bamako by 2001. Improvement of navigation facilities has not been implemented. Irrigation development has been slower than planned, with only 131,000 ha irrigated by 1998, and only half of that area being cropped on average. The major beneficiary of the Manantali and Diama dams was the development of irrigated sugarcane at Richard Toll by the Senegalese Sugar Company, based on a steady water supply above Diama Dam.

Inadequate agricultural and health planning, however, resulted in a major crisis in health and nutrition beginning in 1987, especially the schistosomiasis epidemic at Richard Toll, which is discussed in more detail below. The Manantali and Diama dams also reduced the variety of ecosystems in the valley, benefiting monocultures such as sugarcane but also resulting in aquatic weed nuisances and water-associated disease vectors. Embankments on both sides now control flooding along the Diama Reservoir up to Dagana. Irrigation systems are labor intensive, however, leaving little time for traditional crops that previously were the major nutrition source for most households. Government-supported rice production has used up farmers' cash income, which also had provided variety in diet. Malnutrition is most noticeable among women and children, as well as ethnic minorities. Overall, the basin ecosystems and production systems are now threatened by decreasing productivity because of inadequate resource management, including deforestation, soil erosion, overgrazing, and desertification. Species diversity has been reduced, along with elimination of wetlands by diking and expansion of irrigated areas. There are enormous social costs including malnutrition, disease, civil unrest, and social conflicts. Morbidity and death are increasing as a result of malaria, schistosomiasis, and diarrheal diseases, which were formerly held in check by the annual dry season.

Opportunities exist for capacity building and regional cooperation in monitoring of riparian ecosystems and agricultural productivity. Consequent improvement in environmental management is the key to maintaining political and economic equilibrium in the SRB. Action should be initiated on (1) improving regional cooperation on water resources and environmental management, (2) data collection on hydrology and sediment regimes, (3) developing small hydrodams and irrigation systems, and (4) wildlife and biodiversity conservation. Available data are either confined to national sub-basins or to single resources. Historical records on flow and rainfall exist from Saint-Louis up to Bakel, but recent changes in rainfall and flow are not yet included in the planning process. General ecological data for the entire watershed are needed, which would make use of remote sensing, cartography, and ground monitoring, especially in the upper basin. Further work should be focused on the needs for development of the SRB riparian communities.

Geospatial Data Availability and Clearinghouse Developments in Countries of the Senegal River Basin[3]

The International Program of the U.S. Geological Survey's Earth Resources Observation Systems (EROS) Data Center participates in several research and development activities in the countries of the Senegal River basin. The Famine Early Warning System Network (FEWS NET) program, discussed in further detail below, has secured and makes available from its Africa Data Dissemination Server several core data sets for the countries. These are maintained in the EROS Data Center archive, are freely available, and are routinely updated. The program also generates several dynamic data sets that are presented in near real time and that include spatially distributed rainfall estimates, water runoff estimates, a normalized difference vegetation index, and crop-water saturation indexes. These are also accumulated in the archive and are available for some online access, processing, and downloading.

A current project on carbon sequestration in Senegal is generating estimates of carbon stocks and fluxes in three defined geographic areas: Velingara, Bambey, and Podor. These are defining the biophysical potential for sequestration as impacted by climate and land-use management, and the socioeconomic incentives for various management practices.

Extensive work in Senegal has provided documented information on natural resources, land cover, and land-cover change over periods covering as much as 60 years. These data are both in the form of reports and digital maps. Conversions of gallery forests, for example, along the Senegal River are clearly docu-

[3] Based on a presentation by Larry L. Tieszen, Earth Resources Observation Systems (EROS) Data Center, U.S. Geological Survey, Sioux Falls, South Dakota, USA.

mented. Techniques to evaluate changes in the performance of land cover (e.g., greenness level, start of growing season) at the pixel (1 km) level have been developed. These identify temporal trends in land-cover performance associated with land degradation (e.g., near boreholes or large cities) or spatial anomalies, which suggest degradation or improvement, associated with conserved areas and other management practices. These anomalies are verified with high-resolution satellite imagery or ground observations.

The EROS Data Center has developed clearinghouse systems for the identification, access, and distribution of spatial data. In the SRB countries the Centre de Suivi Ecologique has already received the appropriate software and is initiating this system consistent with the standards established by the International Organization for Standardization.

Weather and Climate Data, Analyses, and Applications[4]

Weather and climate are essential concerns of human existence. Data about weather and climate describe and quantify variable resources such as wind, rain, and temperature that are shared by everyone and are sometimes contested. The outcome of policies adopted by governments as well as individuals in managing food production, water supplies, natural ecosystems, and health services can be heavily influenced by the quality of available weather and climate information. As decision making and concepts of sustainable development look further into the future, the assembly and analysis of weather records and the creation of information products become more complex and more important. Weather and climate information can help in monitoring and assessing many environmental parameters and problems, including agricultural production and fresh water supplies. Global and regional data provide means to check the quality of local data, place local climate patterns into a larger context, and lend confidence and credibility to analyses that are important to environmental effects in the Senegal River region.

Observations and records of weather variables important to Senegal extend across the country and well beyond its borders. Accordingly, while observation and data management systems within the country should be improved, they must also comply with regional and international collaboration. New sources of data are being added all the time, such as the ones at the EROS Data Center. However, these sources must be integrated into the existing methods of analysis, and the influence of these new data sources on the traditional analysis schemes must be understood well enough to engender confidence by those who would apply them.

Meteorological and climatological data are available on the World Wide

[4] Based on a presentation by William A. Sprigg, University of Arizona, Tucson, Arizona, USA.

Web from many sources. For example, weather data can be obtained from Web Africa, the U.S. National Weather Service, and the European Centre for Medium-Range Weather Forecasts. Information relating to climate impacts can be obtained from the Intergovernmental Panel on Climate Change, which was established by the World Meteorological Organization and the U.N. Environment Programme, as well as from the U.S. National Weather Service's Climate Prediction Center, which hosts the Global Data Display System. Seasonal forecasts for Africa can be obtained from the International Research Institute for Climate Prediction.

The SRB may be a good candidate for the International Watershed Research Network. This network, which is in its conceptual phase, has as its objective to advance understanding of watershed processes, and draws upon shared expertise from watersheds around the world.

Data Availability at the National Oceanic and Atmospheric Administration (NOAA) for Environmental Monitoring over the Senegal River Basin[5]

The data set available at NOAA for climate monitoring over the Senegal River basin includes in-situ and satellite-derived data and information. The in-situ data are received daily through the World Meteorological Organization's Global Telecommunications System (GTS). These data are fed into NOAA's databases to construct climatology information based on several parameters, including rainfall, temperature, and wind, and to derive near-real-time anomalies for those parameters at time scales ranging from 10 days to monthly and seasonal. Satellite-derived rainfall estimates are produced using the newly developed NOAA satellite rainfall estimation technique (RFE). RFE is primarily based on (1) GTS rain gauge measurements; (2) the Geostationary Operational Environmental Satellite (GOES) Precipitation Index, a technique that derives rainfall estimates from fractional cloud coverage colder than 235 K obtained from Meteosat infrared data; (3) Special Sensor Microwave/Imager (SSM/I) rainfall estimates; and (4) Advanced Microwave Sounding Unit (AMSU) rainfall estimates. RFE is produced operationally at NOAA's Climate Prediction Center for the USAID Famine Early Warning System (FEWS) in support of weather- and climate-related hazard assessments in Africa.

Difficulties are encountered in obtaining local in-situ data, primarily because of telecommunication problems. NOAA's database contains long-term historical data for only six rain gauge stations over the SRB. A new approach for more dense data coverage and to address the telecommunication issues is being developed.

Correlations between Sahel rainfall and global SST are being developed for

[5] Based on presentation by Wassila M. Thiaw, Climate Prediction Center, National Centers for Environmental Prediction, Washington, D.C., USA.

predictive purposes. Other prediction methods are also being investigated at NOAA and many other world centers for climate forecasting. This has led to the development of Climate Outlook Forums,[6] which were initiated by NOAA in 1997. These forums have brought together both forecasters and users of climate information not only to bridge the gap between them but also to issue a readily available consensus forecast, which can be interpreted easily by the users. Forecasts are given in above normal, normal, and below normal probabilistic categories, and various types of decision makers are now involved in the process.

Remote-Sensing and Hydrologic Tools for Flooding in Africa: Zambezi, Limpopo, and Senegal Watersheds[7]

Worldwide, flooding causes loss of life and extreme damage to property on an almost annual basis, and Africa is no exception. In 1999 floods in the Senegal watershed and many other parts of West Africa killed several hundred people and left thousands homeless. The February-March 2000 floods in the Limpopo watershed cost more than 900 lives and caused extensive damage to infrastructure, while the 2001 floods in the Zambezi watershed were responsible for more than 100 deaths. Although intense flooding often causes much damage, floods also provide the main source of livelihood to many people through flood-recession cropping, which is how the Senegal River valley below Bakel was farmed prior to the construction of the Manantali Dam. With such a paradoxical scenario the ability to tell in advance the nature of impending floods becomes necessary, so that any required preparatory action can be taken. Thus, the ability to accurately predict the timing, spatial extent, and volumes associated with a flood event is a fundamental aspect of floodplain management. Toward this end, FEWS NET through its implementation partners has developed a flood modeling and prediction tool, the FEWS Stream Flow Model (SFM), to allow the timely provision of early warning information on flooding in Africa. This tool is now fully operational for the Limpopo watershed and is currently being calibrated for other watersheds in Africa.

While the SFM provides valuable estimates of stream flow (and hence river stage), a second crucial component of flood information pertains to the spatial patterns and extent of flooding, an issue that can be addressed using fine-resolution satellite images. The Global River Floodplains (GRF) project has developed

---

[6] A Summary of the Regional Climate Outlook Forums in Africa, prepared by Wassila Thiaw and Frederick Semazzi, can be found at http://www.cpc.noaa.gov/products/african_desk/rain_guidance/forum_report.html.

[7] Based on presentation by T.T. Magadzire, University of California, Santa Barbara, USA, as well as work done by L.A.K. Mertes, University of California, Santa Barbara, USA, and J.P. Verdin, EROS Data Center, U.S. Geological Survey, Sioux Falls, South Dakota, USA.

a database identifying remote sensing images for many large rivers in the world. The National Aeronautics and Space Administration Moderate-resolution Imaging Spectrometer (MODIS) and Landsat images identified through the GRF database have been processed and analyzed to derive maps showing the extent of inundation and patterns of sediment concentration for significant flood events in the Zambezi and Limpopo watersheds. Analysis of these satellite images shows where local water that accumulates on a floodplain before overbank flooding occurs contributes significantly to the patterns and extent of inundation, thus helping to improve the accuracy of the predictions from the FEWS SFM model.

Initial work on the Senegal watershed involves an analysis of the flood events over the past 25 years, the morphometric characteristics of stream order, and the drainage density patterns within this watershed. In particular, the characteristic temporal and spatial patterns of drought and flood within the Senegal watershed were derived using results from U.S. Geological Survey climate modeling and are compared to the selected remote-sensing images.

Data Needs for Environmental Models[8]

Environmental models require a large number of data sets to run and test the models. The most critical data include (1) soil physical data, (2) atmospheric weather data, (3) vegetation characteristics, and (4) current and historical land-use data. Although the data needs for the environmental models are model specific, there are standard data sets used by most environmental models. The time step of the models has a big impact on the data requirements of the models. Monthly time-step models typically require (1) monthly total precipitation and monthly averaged daily maximum and minimum temperatures as atmospheric drivers, (2) soil texture, bulk density and field capacity, and wilting point as required soils data, and (3) a general description of land cover and land-use management. Daily time-step environmental models require more detailed information about the atmospheric driving variables (daily total precipitation, daily maximum and minimum air temperature, wind speed, relative humidity, and solar radiation) and soils data (e.g., saturated and unsaturated hydraulic conductivity, and water potential versus soil water content).

Fortunately a large number of environmental data sets are available at the local, regional, and national level for the important atmospheric driving variables, soil description data, and land-cover data. For instance, global data sets at the 0.5 * 0.5 degree scale are available for daily and monthly atmospheric driver data, soil-texture data, and land-cover and use data. More detailed soil physical data can be derived from the soil-texture data, and a coarse historical analysis of

[8] Based on presentation by William J. Parton, Natural Resources Ecology Laboratory, Colorado State University, Fort Collins, Colorado, USA.

changes in land use has recently been developed. The atmospheric driving data, soil characteristics, and land-use data are available on a finer spatial scale (e.g., 30 * 30 m^2, 5 * 5 km^2) for select regions of the world.

Regional data sets are available to describe the spatial patterns of the major environmental variables for the SRB. These data sets describe land use, climatic variables, and soils data needed to drive ecosystems models. The data sets have been interpolated to the 0.5 * 0.5 degree resolution at the global scale and are available from the Century Ecosystem Modeling group:[9] (1) 1900-1998 monthly precipitation, (2) 1900-1998 monthly average maximum and minimum air temperature, (3) potential natural land-use patterns, and (4) soil-texture description (e.g., sand, silt, clay content). These driving variables have been used to simulate the global patterns of the major ecosystem variables using the Century ecosystem model.[10] The patterns of the Century model output variables have been simulated for the past 100 years using weather data sets that are interpolated to the 0.5 * 0.5-degree global scale. There are over 300 output variables from the Century model available to represent the status of the major ecosystems variables. Some of the important ecosystems variables include annual and average total plant production, soil carbon and nitrogen levels (0-20 cm soil depth), plant production for the tree and grass components of the ecosystem, stream flow, actual evapotranspiration, and soil nitrogen mineralization rates. These output variables are available at monthly, annual, or long-term averaged time scales for the SRB region for the last 100 years.[11]

HEALTH ISSUES AND RELATED DATA

In-situ Data Resources on Health Impacts of Manantali, Diama, and Foum Gleita Dams[12]

Since the great West African drought that ended in 1974, concerns about health impacts of water resources development have been a high priority in the SRB. The first dam constructed in the basin was at Foum Gleita in Mauritania on the Gorgol River, the only tributary of the Senegal River in Mauritania. Health data on water-associated diseases were collected specifically for this dam by Blue Nile Associates in 1974 prior to construction, and a few health surveys were carried out several years after construction.

Planning for the Manantali Dam on the Bafing River tributary in Mali and

---

[9] See http://www.nrel.colostate.edu/projects/century for the Century Ecosystem Modeling Web site.

[10] D.S. Schimel, B.H. Braswell, and W.J. Parton. 1997. "Equilibrium of the terrestrial water, nitrogen, and carbon cycles," *Proc. Natl. Acad. Sci.* 99:8280-8282.

[11] Scientists interested in obtaining output from these model runs can contact the Century Web site at http://www.nrel.colostate.edu/projects/century.

[12] Based on presentation by William Jobin, Blue Nile Associates, Cortez, Colorado, USA.

Diama Dam near the delta included several health surveys conducted for OMVS at the request of the World Bank, which was financing both projects initially. The largest study was sponsored by USAID in 1978 and conducted by Gannett Fleming. There were pre- and post-construction surveys at Manantali by the Institut Nationale de Recherche en Santé Publique, or the National Institute for Public Health Research, of Bamako, as well as surveys by Blue Nile Associates and the Water and Sanitation for Health Project of USAID. A limnology unit of the OMVS stationed at Manantali Dam started collecting data on disease vectors in the reservoir soon after construction. Disease epidemics around Diama Dam began the year after the dam was completed, and a large number of surveys on water-associated diseases have been conducted around Diama by local and foreign universities and agencies almost every year since then. The Onchocerciasis Control program of the WHO collected data on river blindness and its spread by blackflies in the upper basin until the disease was controlled, which occurred around about 1990. USAID sponsored a study on AIDS in the valley in 1995. A large amount of clinical data on all diseases is found in ministries of health units of all three countries along the river, with the most extensive being in the Saint-Louis and Rosso areas. The Senegalese Sugar Company maintains its own clinic and medical records in Richard Toll as well. However, records found in various ministry offices in capital cities are of little use in epidemiologic evaluations of disease impacts of the river development. Finally, the WHO has sponsored a multitude of disease surveys along the river, starting with Watson's survey of 1970. These may be found at the WHO country offices but are no longer in the central library in Geneva.

The Strategic Direction for Research on Schistosomiasis at the World Health Organization (WHO)[13]

Schistosomiasis control has been implemented successfully in certain areas and in many countries over the past 20 years. However, the number of people infested has not changed substantially and disease burden remains high. The potential for transmission has increased due to water resource developments, with many more people living in endemic areas. About 600 million people live in schistosomiasis areas, of whom approximately 200 million are infested, 120 million symptomatic, and 20 million with severe disease; several hundred thousand die each year from urinary and intestinal complications.

Over the same period, the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR) invested in research to develop tools for the control of schistosomiasis and other tropical diseases. This re-

[13] Based on presentation by Lester Chitsulo, UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases, Geneva, Switzerland.

search ranged from basic sciences to the "proof of principle."[14] TDR and its partners evaluated the effectiveness of drugs, validated a range of diagnostic techniques, and investigated measures of schistosomiasis morbidity. TDR has also built capacity for scientists from disease-endemic countries to participate in this research. The reintroduction of a disease perspective and the strengthening of implementation research in the strategy of TDR has resulted in the reassessment of the research needs in schistosomiasis. While new tools for the control of schistosomiasis are necessary, more work needs to be done to optimize the use of existing tools in resource-limited environments and to formulate new strategies for control. The TDR strategic direction on schistosomiasis research is focused on this objective until an extensive review by a Scientific Working Group in 2005. WHO also supports related data collection, database development, and data access.

The officially commissioned Environment and Health Impact Analysis of the planned Senegal River dams did not anticipate the schistosomiasis problem. This was because the people who did the assessment were experts in snails and schistosomiasis but not dams. Neither were other dams (e.g., Aswan, Upper Volta) considered in the assessment. By 1994 a significant proportion (more than 90 percent) of the population living along the Diama reservoir was infested. Several surveys conducted in communities near Richard Toll showed that virtually everyone above five years of age had *S. mansoni* infestation. Schistosomiasis has been controlled in China, Brazil, and North Africa but not in the Sahel.

Proliferation of Snails That Are an Intermediate Host of Human and Animal Trematodosis[15]

Malacological fauna, especially snails, are the intermediate host of human and animal trematodosis (a parasitic flatworm). This has been studied in the SRB, particularly in the delta and Lac de Guiers areas. Surveys conducted from 1978 to 1980 identified the potential of natural snails in the transmission of trematodosis. Among these snails are five species of Bulinus: *B. truncatus, B. forskalii, B. senegalensis, B. umbilicatus, B. globosus*; one species of Biomphalaria: *Biomphalaria pfeifferi;* and one species of Lymnaeidae, *Lymnaea natalensis*. *Bulinus truncatus* was the most widespread and abundant snail. The *B. senegalensis* and *B. forskalii* snails were less extensive and had lower densities. *B. umbilicatus* had restricted distribution in the middle valley, whereas

[14] Proof of principle refers to research that shows that a new tool or drug works in a controlled setting.

[15] Based on presentation by Oumar Talla Diaw, Laboratoire National de Recherches Vétérinaires, Dakar, Senegal. Please note that Dr. Diaw was unable to attend this workshop due to illness.

Biomphalaria pfeifferi, Lymnaea natalensis, and *B. globosus* were found very sparsely distributed in some sites with small populations.

Ecological changes, particularly physical and chemical changes in the water environment, resulted from the opening of the Diama and Manantali dams. The more important changes for the ecology of the snails are the prevention of the intrusion of sea water into the Senegal River, the regularization of the level of water in the river and other effluents in the delta, and the pH of the water becoming more alkaline. The combination of these factors has provided new favorable conditions facilitating the growth, spread, and increase of snails.

Malacological surveys that were carried out in the delta and Lac de Guiers from 1989 to 1996 revealed very large changes in the distribution and abundance of snails. The main signs of these changes were the rapid proliferation of *Biomphalaria pfeifferi* and *Lymnaea natalensis* molluscs, which seemed to have disappeared in 1977, while populations of *Bulinus globosus* had colonized more sites in the delta and Lac de Guiers with high densities. The other Bulinus had remained stable. These changes in ecological conditions have allowed these species of snails to flourish by colonizing more habitats, increasing substantially their population size, and extending their distribution. Another remarkable finding in the recent studies was the colonization of the Senegal River by the snails *Biomphalaria pfeifferi, Bulinus globosus,* and *Lymnaea natalensis*. Generally, these intermediate host snails are reported to occur only scarcely in large rivers like the Senegal River.

Because the optimal ecological conditions favorable to the growth and increase of snails have been created, it is easy to imagine the consequences of this situation in the epidemiology of snail-borne diseases in the SRB. The first outbreak of intestinal schistosomiasis in humans was in the delta town of Richard Toll in 1988-1989.

After Diama Dam became operational and many hydro-agricultural activities were set up, an increase in animal trematodosis was observed in the SRB as well. It concerned in particular *Fasciola gigantica, Schistosoma bovis, S. curassoni,* and *Paramphistomum sp*. The cattle trematodosis epidemiology showed itself in the disease prevalence increase in existing foci (Richard Toll, Ross Bethio, Mbane, and Keur Momar Sarr). Infestation rates in cattle increased from 11 percent to 27 percent, 20 percent to 30 percent, and 15 percent to 27 percent for fasciolosis, paramphistomosis, and schistosomiasis, respectively. In small ruminants, which seemed spared, 2 percent to 62 percent fasciolosis prevalence rates were recorded, whereas they were 25 percent to 30 percent for paramphistomosis. In a parallel manner new trematodosis foci appeared, starting in 1989 to 1990:

1. At the delta area in Tilene, Pont Gendarme, and Takhembeut with 3 percent to 20 percent, 4 percent to 20 percent, and 5 percent to 36 percent prevalence rates for fasciolosis, schistosomiasis, and paramphistomosis, respectively; and

2. At the Lac de Guiers area in Temeye, Thiago, and Senda with 5 percent to 86 percent, 5 percent to 11 percent, and 5 percent to 33 percent prevalence rates for fasciolosis, schistosomiasis, and paramphistomosis, respectively. In these new foci 2 percent to 55 percent and 5 percent to 25 percent prevalence rates were recorded in small ruminants for fasciolosis and paramphistomosis, respectively. Schistosomiasis was not as frequent, with 2 percent to 4 percent prevalence rates. This new trematodosis epidemiology after the opening of dams was remarkable by its very high infestation rates and parasite burdens, and by a polyparasitism that combined *Fasciola gigantica, Schistosoma bovis, S. curassoni,* and *Paramphistomum sp*.

SOCIOECONOMIC ISSUES AND RELATED DATA

An Atlas on Population, Food, and Environment: Senegal River Basin and CILSS Member Countries[16]

This atlas presents the results of a temporal and spatial analysis of the relations between population factors, agricultural land use and performances, nutrition, and land degradation. The geographic area included in this project covered four CILSS member countries: Burkina Faso, Mali, Niger, and Senegal. Using a GIS, this study shows the interplay of these indicators at different scales (subregional, national, and local [first administrative level]). It represents a contribution to structural analysis of vulnerability and is a first step toward a decentralized (at the district or at village-clusters levels) decision-support system for an integrated strategic plan linked to an early warning system targeting poverty alleviation in the SRB.

The methodology for developing the atlas was based on the integration of multiple sources of data on population, including censuses, West African survey on migrations and urbanization (1988-1992), agriculture (national statistics services and projects, AGRHYMET), infant malnutrition (Demographic and Health Surveys, United Nations Children's Fund), and land degradation (Global Assessment of Human Induced Soil Degradation Web site). The database was developed using Excel and mapping with GIS software called ArcInfo. However, substantial difficulties arose in obtaining some of the data.

The atlas produced a number of usual and also innovative indicators for the 1984-1985 to 1996-1997 period, although not systemized for the SRB. These data included:

---

[16] Based on presentation by Hamdou-Rabby Wane, Charge de Programme, CERPOD/INSAH, Bamako, Mali, and Visiting Research Fellow, Watson Institute, Brown University, Providence, Rhode Island, USA.

1. density levels and migratory rates and surface of cultivated land (per rural habitant, rural worker); production (per rural habitant, rural worker) of the different crops; and land degradation.

2. migratory rates and level of intensification per worker according to the type of rain-fed crops.

3. length of the growing season and carrying capacity (1985-1997 period) per hectare-surface; and rural worker.

4. comparisons of the rate of coverage of the household's caloric needs by the local production and actual level of stunting and wasting.

The atlas still needs additional data and analytical improvements. Data collection needs include a survey on individuals' life-cycle events (family, activity/employment, land cultivation and tenure, migration); village community surveys on land-cover/land-use issues, history of production and social infrastructures, and markets; and remote sensing (1-m resolution) on land use and land quality (wind and water erosion sensitivity, salinization) changes. Information technology needs include Web-based research and mapping.

The atlas was first disseminated at the Conference of CILSS ministers and summit of CILSS heads of state at Bamako, Mali, in November 2000. An atlas Web page is also under construction (see www.insah.org).

ISSUES CONCERNING DATA FOR DECISION MAKING ABOUT DAM PROJECTS

The Report of the World Commission on Dams—An Advocacy for an Improved Information Base for Sustainable and Equitable Management of Water and Energy Resources[17]

The World Commission on Dams (WCD) was established in 1997 under the auspices of the World Bank and the World Conservation Union with a three-pronged mandate of (a) undertaking a rigorous and independent review of the development effectiveness of large dams; (b) assessing alternatives; and (c) proposing practical guidelines for future decision making. The WCD carried out its activities from May 1998 to November 2000.[18]

Regarding the first prong, the WCD conducted the first comprehensive study on the impacts of dams, but was unable to declare a "final verdict." Lack of both baseline and impact data was one of the major constraints to arriving at a definite

[17] Based on teleconference presentation by Madiodio Niasse, IUCN Wetlands and Water Resources Programme, Ouagadougou, Burkina Faso.

[18] See World Commission on Dams. 2000. *Dams and Development: A New Framework for Decision-Making*. London and Sterling, VA: EarthScan Publications.

conclusion on the development effectiveness of large dams. The same applies to the second prong of the WCD mandate—the non-dam options for delivering water and energy services. Regarding the third prong, the WCD recommended that the planning process related to water and energy development be moved upstream, starting with a needs assessment and/or validation and followed by an options assessment. These two critical stages should take place before a dam emerges as the preferred option. A good quality information base needs to be established at the national and river basin level as a long-term effort, whether a dam is planned or not.

Once an intervention is selected the subsequent decision-making stages are project planning, construction, and operation. At these stages the WCD recommended systematic baseline feasibility and impact studies, with an emphasis on such parameters as costs (financial and economic, environmental, social, health, cultural heritage), benefits, and distributional aspects that deal with the sharing of impacts.

Overall, the WCD report proposed a highly data-intensive, decision-support system. Many of the 26 WCD guidelines relate to data collection and analysis: stakeholder analysis, strategic impact assessment, project-level impact assessment, multicriteria analysis, life-cycle assessment, assessment of greenhouse gas emissions, distributional analysis, valuation of social and environmental impacts, risk assessment, baseline ecosystem surveys, baseline socioeconomic surveys, and environmental flow assessment. Because of its heavy reliance on a good information base, some critics have questioned the adaptability of the WCD proposed decision-making framework to the context of developing countries. The question however is: Is there an alternative to a good information base for informed decision making?

As a follow-up to the WCD report the UNEP Dams and Development project "promotes dialogue on improving decision making, planning and management of dams and their alternatives based on the WCD core values and strategic priorities."[19]

Using GIS to Identify Opportunities for Cooperation in International River Systems[20]

Despite the growing literature on water and conflict in international river basins, little empirical work has been done to bolster common conclusions that

[19] Additional information on this project can be obtained from the UNEP Dams and Development Web site at http://www.unep-dams.org.

[20] Summary of a study by Aaron T. Wolf, Shira Yoffe, and Mark Giordano, Department of Geosciences, Oregon State University, USA, and given by Prof. Wolf during a teleconference at the workshop.

are so widely reported. In order to address this gap Wolf, Yoffe, and Giordano assessed all reported events of either conflict or cooperation between nations over water resources over the last 50 years and used these events to inform the identification of basins at greatest risk of dispute in the near future (5 to 10 years). The study was divided into two components:

1. Compilation and assessment of relevant biophysical, socioeconomic, and geopolitical data in a global geographic information system, and use of these factors to determine history-based indicators for future tensions along international waterways; and
2. Using these indicators, identification of basins at risk for the coming decade.

In general the study found that most of the parameters regularly identified as indicators of water conflict are actually only weakly linked to dispute. The institutional capacity in a basin, however, whether defined as water management bodies or treaties or generally positive international relations, are as important, if not more so, than the physical aspects of a system. It turns out, then, that very rapid changes, either on the institutional side or in the physical system, are at the root of most water conflict, as reflected in two sets of indicators: (1) "internationalized" basins (i.e., basins that include the management structures of newly independent states) and (2) basins that include unilateral development projects and the absence of cooperative regimes. By taking parameters of rapid change as indicators—internationalized basins and major planned projects in hostile and/or institution-less basins—the study was able to identify the basins with settings that suggest the potential for tensions in the coming 5 to 10 years. The study then identified "red flags," or markers, related to these indicators, so that monitoring in the future might continue to help identify targeted regions for cooperation.

Complementing Data: Elements of Decision Making for Natural Resource Management in the Senegal River Basin[21]

The lack of comprehensive scientific data and access to existing data is only one barrier to responsible decision making in formulating a sustainable development plan for the SRB. As noted earlier, the objectives of the OMVS in building the two dams on the river was to improve navigability, provide irrigation water

[21] Based on a presentation by Kristine McElwee, formerly of the College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon, USA, and now with the National Ocean Service Pacific Services Center. The results were based on the cooperation and guidance of researchers at the Centre de Recherches Océanographiques Dakar-Thiaroye, interviews with local Senegalese agency and university personnel, and a literature review.

for more intensive and reliable agriculture, and produce hydroelectricity. Since the dams' construction these goals have proved more difficult to attain than originally anticipated. Many negative effects of the dams' construction were either unanticipated or underestimated. In the SRB "sustainable development" was heavily weighted toward technological improvements that would help propel Senegal, Mali, and Mauritania into the first world, with relatively less regard for the impact on indigenous social values and structures. As new data have emerged on the ecological, health, social, and cultural effects of the dams' creation and operation, effective policy making and reevaluation remain encumbered by the original paradigm—modernization through technological development. An optimal decision-making process ideally would be inclusive of all uses of the river, from headwaters to the ocean, and fully take into account the input of all stakeholders. The challenge of sustainable development of natural resources is to implement adaptive management, responding to changing conditions, priorities, and information. That such changes have not yet occurred in the SRB's management illustrates one of the difficulties of natural resource management: Decisions are rarely made on the basis of data alone.

4

Summary of Issues Raised by the Participants at the Workshop

The workshop presentations and panel discussions identified a number of key scientific, technological, institutional, and policy issues regarding data for decision making toward sustainable development of the SRB. These are summarized below. While they are representative of the views expressed by many of the participants, they do not constitute formal consensus conclusions or recommendations.

SCIENTIFIC DATA ISSUES

- Because the livelihoods of so many people depend on water from the SRB or access to the water, and because the quality, movement, and temporal extent of the water all determine aspects of human and livestock health, the broader basin needs to be studied in its totality. One could argue that because of socioeconomic connections outside the basin, and the fact that policy is determined in each country outside the basin and even at some distance, an even broader spatial view should be considered.
- The issues and problems confronting the management of the SRB are multisectoral and multidisciplinary, and their resolution will require data and information from many areas and sources. A shared knowledge base founded on factual, objective, and reliable data is essential to addressing these problems. As has already been amply demonstrated throughout the history of the dams in the SRB, any significant management decision will have diverse and complex results because of the ecological interactions

involving multiple causal relationships and feedbacks. It is nonetheless largely a constrained and scientifically manageable system because its immediate area of geographic importance is largely watershed based and many of the problems, such as endemic malaria and schistosomiasis, are well understood from other aquatic systems. The data that are needed include static data (e.g., soils, topography) and dynamic data (e.g., rainfall estimate, NDVI, infectivity rates, crop yields, and water flow). These dynamic data will vary by time scales, ranging from 15 minutes to weekly to annual.

- There is a lack of baseline data, an inability to compare data, an inability to even find documents, and a serious time lag between data acquisition (e.g., stream flow) and availability. In a system where timing of artificial floods, saltwater intrusion, and other variables are critical for agricultural and health management, these problems portend serious management issues with major consequences for human health and livelihoods, issues that have earlier resulted in significant conflict.
- There is a need to identify and assess the status of all data resources concerning the SRB (not only the ones identified through this workshop) to establish a baseline and comprehensive directory that is online. What data are available, what is their quality, what is their relevance, and what are the critical gaps? The OMVS has a lot of information, but it is unclear how much and it is not yet digitally accessible.
- There also are many foreign data sources (e.g., U.S. and French government satellite data) that are relevant, as well as a wealth of information based on experience in managing other river systems. All of these external information resources should be considered in addressing SRB problems.
- A predictive scenario-modeling approach would be useful for addressing some SRB issues.
- The relationship of health and environmental factors is hard to determine and the integration of data from these (and other) diverse discipline areas is therefore difficult.
- The role and value of traditional or indigenous knowledge is underappreciated in many studies dealing with the SRB.
- There appears to be a growing realization by the scientific community that individual researcher data should be made available. This is much more prevalent in the environmental area than in biomedicine. Barriers to data sharing in biomedical research include intellectual property concerns, privacy, longitudinal studies, individual research as opposed to large observational team projects, and the heterogeneity of such data.
- Scientists who are involved in research and data activities related to the SRB ought to assume more responsibility to work on solutions for the most pressing problems and to communicate their findings to decision makers and the public more effectively.

TECHNOLOGICAL DATA ISSUES

- There is a wide disparity in technological capabilities for SRB data and information management and use. This became clear to workshop participants during two site visits. Although the personnel in the OMVS Documentation Center had the expertise to meet substantially higher technology standards, they lacked most basic information technology capabilities, including Internet connectivity. Effective Internet links will be essential for deriving maximum benefits from distributed digital data holdings throughout the region, and beyond.
- There is a need to have a standardized, modern cartographic GIS as a tool to integrate the diverse data resources in support of various decision-making and policy-formation activities, both for the SRB and for many other applications and geographic areas.
- Other computational tools are needed to model and assess agricultural, environmental, and hydrological processes. Many of the key data sets are available and so are the techniques for modeling and simulation. The main hurdle, as with many other needed improvements, is a lack of money, rather than the requisite technology or expertise.
- Radios are the most widespread means of information dissemination and this could be better exploited. For example, the Republic of Guinea used remotely sensed data in rural radio programs to disseminate information regarding bush fires. This showed that information could be used to limit fires by providing warning of fires when they occur to help limit their spread and loss of life.

INSTITUTIONAL DATA ISSUES

- Improving the coordination of existing institutions and projects is a key concern. For example, the OMVS and CSE activities are not adequately linked. A network of all other relevant data-holding institutions in the SRB region as well as internationally could be formed to share data and information in an integrated manner.
- The CSE might consider viewing its role as a clearinghouse for a national and regional spatial data infrastructure. A clearinghouse is not centralized but designed as a distributed data center connected through the Internet. There is no physical transfer of actual data holdings; the distributed data are made available through separate servers containing structured data and metadata. A comprehensive strategy for a GIS-based geospatial data clearinghouse is important to address these needs successfully. This would go a long way toward linking and integrating the data holdings of all the separate institutions and individual researchers.

POLICY ISSUES REGARDING DATA FOR DECISION MAKING

- There is a need to take better advantage of the SRB data that are collected and to establish early warning and vulnerability links. Scientific data in particular need to be used and integrated from research into policy and decision making whenever appropriate. The process for this may be simply described as follows: data → information → knowledge → understanding → decision making at different levels. Education of the policy makers and the population is very important to this process, but the data need to be relevant to policy formation first. It is essential to learn from and avoid the mistakes made in the past that were raised in some of the presentations.
- There is a role for the scientific community in the policy process. Scientists can act as "policy entrepreneurs" to help bring issues to the attention of decision makers and the public, and particularly by cooperating with OMVS and its senior management and technical staff.
- For data collection and analysis, as well as for the use of the data in decision making, there are political and ideological biases and barriers. An important issue is the requirement for clear credibility on the part of the data holders and decision makers in the SRB. This requires or would be aided by a high level of transparency in the data holdings as well as in the decision-making process. An up-to-date and complete Web-based system with a geospatial clearinghouse for both spatial data and relevant documents would go a long way toward achieving such transparency.
- Related to the immediately preceding issue is the need to involve all stakeholders, including the people from the communities directly affected, in the problem management and policy formation. Potential participants in decision making include government agencies, industry, nongovernmental organizations, and the public, which would include representatives of local inhabitants and fishermen, herders, and farmers (both flood-recession and irrigation).
- Who the messenger is can be as important as what the message is. There is a need to use trusted people who speak the local language in converting and diffusing the knowledge derived from the original data into relevant public action. For example, an HIV awareness initiative used a national and regional network of journalists who were given advance training with a grants program. A network of religious leaders was also used. Another example from beyond the region was educating the public about how to avoid conditions that might lead to infection by Hanta virus in Arizona. The approach was to get warnings out through the television weather reporters, who were found to be the public figures to whom most people listened most often. There needs to be public acceptance, not just top-down decisions, even if they are based on accurate data.

- For poor countries the requirements for collection of comprehensive and reliable data are nonetheless seen by many as a luxury that benefits an army of consultants but not the poor people. It is therefore important to prioritize and adequately justify the data collection activities and especially to make them subsequently available as widely as possible in order to derive maximum value from their use. The data collection activities should be linked to an analysis of comprehensive baseline data, to an assessment of information needs, and to an analysis of regional and national development policy and options. An approach found successful elsewhere to make the data available is to use these data in university teaching of scientific method and environmental assessment, and other educational exercises. Not only are results contributing to current knowledge but they also multiply potential users many fold through the graduating students who move on to responsible careers in government, academe, and industry.
- The capital cities of Mauritania, Senegal, and Mali (Nouakchott, Dakar, and Bamako, respectively) are located outside of the SRB, and there appears to be a disconnect between the decision making in these cities and local needs. A disconnect also exists between Saint-Louis, where the Diama Dam is located, and Dakar, where the OMVS is headquartered. The broad availability of relevant data and information online would help mitigate those asymmetries by linking regional executives and administrative entities ("communes rurales" and "urbaines") in the SRB.
- The absence of Guinea in the OMVS has weakened the success of the water management and infrastructure development, operation, and maintenance because of the lack of upper basin data for planning and management purposes.
- River basins have historically been a meeting place for people of different cultures and ideologies. This attribute, along with a focus on science, is being used today in the formation of an International Watershed Research Network. Tapping an international cadre of scientists and engineers, the network is a means to standardize measurement techniques, analyses, and data management for the benefit of those within the basin and those extant who would apply the knowledge gained from one watershed to another. Joining this network would address many of the issues raised herein: data sharing, intercomparability of measurements and analyses, access to standardized technology, international shared expertise, effective applications, and institutional coordination.

APPENDIXES

Appendix A

Site Visits and Workshop Agendas

AGENDA FOR SITE VISITS ON 11-12 MARCH 2002

Monday, March 11

Site visit to the Diama Dam, Université Gaston Berger de Saint-Louis, and OMVS

06:45	Depart by bus from hotel
12:15	Tour of Diama Dam and the CyberCampus of the Université Gaston Berger with Mr. Oumar GAYE, Salta Services International
14:30	Leave for Saint-Louis
14:45	Lunch at l'Hotel de la Poste with officials from the Université Gaston Berger de Saint-Louis • Discussion
16:15	Visit to the OMVS Centre Regional de Documentation with Mr. Mbacké GUEYE, Director, and Alassane TOURE, Chief of Archiving
18:30	Depart for Dakar
22:00	Arrive at hotel

Tuesday, March 12

11:00 Meeting of the CODATA Task Group on African Data Sources

13:30 Meeting of the Organizing Committee Cochairs and Members at Le Meridien President Hotel
- Review of meeting objectives, background materials, participants, and logistics

14:45 All participants depart from the hotel for a site visit to the Centre de Suivi Ecologique in Dakar
- Tour of the facility and discussions with staff

17:45 Return to hotel

WORKSHOP AGENDA

Wednesday, 13 March

08:45 *Welcome and introductions*
Workshop Cochairs: Dr. Abdoulaye GAYE, CODATA Senegal, and Dr. William JOBIN, Blue Nile Associates

Introductory remarks
His Excellency Mr. Fodé SECK, Ambassador, Ministry for Foreign Affairs, African Union and Senegalese Abroad

Introductory remarks
Mr. Donald CLARK, Mission Director, Senegal Office, U.S. Agency for International Development

Overview of meeting goals and agenda
Dr. Paul UHLIR, National Research Council

09:40 Coffee break

Session 1: Health and Biomedical Data Sources
Session Cochairs: Dr. Dialo DIOP and Dr. William JOBIN

10:00 Presentations:

In-situ data resources on health impacts of Manantali, Diama, and Foum Gleita dams in the Senegal River basin: Part 1

Dr. William JOBIN, Blue Nile Associates

The TDR Strategic Direction for Research on Schistosomiasis
Dr. Lester CHITSULO, World Health Organization

Richard Toll, 10 Years Later
Dr. Amadou MBAYE, Programme Espoir (Richard Toll)

Issues for Session 1 and 2 panel discussions:

1. Identify and discuss the various types of existing S&T data and information sources relating to the Senegal River basin that have been created or collected by government, academic, and private sector entities.
2. Discuss the technical, scientific, management, and policy successes and barriers encountered in the collection and creation of the existing data, or that have resulted in the identified gaps.

11:40 Panel discussion on Health and Biomedical Data Sources

12:00 Buffet lunch

Session 2: Environmental, Socioeconomic, and Physical Infrastructure Data Sources
Session Cochairs: Dr. Clement Entsua-MENSAH and Dr. Larry TIESZEN

13:15 Presentations:

Geospatial data availability and clearinghouse developments in countries of the Senegal River basin
Dr. Larry TIESZEN, U.S. Geological Survey

Use of advanced information technology for environmental management: The activities of the Ecological Monitoring Center
Mr. Amadou DIEYE, Centre de Suivi Ecologique

Data availability at the U.S. National Oceanic and Atmospheric Administration (NOAA) for environmental monitoring over the Senegal River basin
Dr. Wassila THIAW, NOAA

Weather and climate data, analyses, and applications
Prof. William SPRIGG, University of Arizona

15:15 Break

15:30 **Session 2 (continued)**

Remote-sensing and hydrologic tools for flooding in Africa: Zambezi, Limpopo, and Senegal watersheds
Mr. Tamuka MAGADZIRE, UC, Santa Barbara

Data needs for environmental models
Prof. William PARTON, Colorado State University

An atlas on population, food, and environment: Senegal River Valley and CILSS-member countries: Part 1
Mr. Hamdou-Rabby WANE, Centre d'Etudes et de Recherche

The overlapping data problem
Dr. Alioune DIENG, ISRA

17:15 Panel discussion on Environmental, Socioeconomic, and Physical Infrastructure Data Sources

17:45 Adjourn

18:30 Dinner

Thursday, 14 March

Session 3: Use of Scientific Data in Decision Making for the Senegal River
Session Cochairs: Dr. Kingsley Oise MOMODU and Prof. William SPRIGG

09:15 Presentations:

Gestion Integreé du Littoral et des Bassins Fluviaux (GILIF): les resultats d'un seminaire
Dr. Per HANSEN, DHI; Dr. Ana NIANG, Tropis Cabinet, and Mr. Seyni COLY

10:05 *Natural resources, environmental issues, and data requirements for the Senegal River basin*
Dr. Mbarack DIOP, TROPICA

10:30 Coffee Break
An atlas on population, food, and environment: Senegal River Valley and CILSS-member Countries: Part 2
Mr. Hamdou-Rabby WANE, Centre d'Etudes et de Recherche

Complementing data: Elements of decision making for natural resource management in the Senegal River basin: Part 1
Ms. Kristine McELWEE, National Ocean Services Pacific Services Center

In-situ data resources on health impacts of Manantali, Diama, and Foum Gleita dams in the Senegal River basin: Part 2
Dr. William JOBIN, Blue Nile Associates

12:15 Buffet lunch

13:30 ***Session 3 (continued)***

Issues for Session 3 panel discussions:

1. Identify and discuss the issues relating to the Senegal River basin that would benefit from the use of existing or potential new data sources.
2. Identify and discuss the technical, scientific, management, and policy successes, and barriers encountered in the use of the existing data.

Panel discussion on the use of health data

15:00 Break

15:30 Panel discussion on the use of environmental, socioeconomic, and ecological data infrastructure data

17:30 Adjourn

19:00 Dinner

Friday, 15 March

Session 4: Improving the Use of Data for Decision Making Toward Sustainable Development

09:00 Presentations:

International rivers: Using GIS to identify opportunities for cooperation
Prof. Aaron WOLF, Oregon State University (by conference call)

Complementing data: Elements of decision making for natural resource management in the Senegal River basin: Part 2
Ms. Kristine McELWEE, National Ocean Services Pacific Services Center

10:00 Break

The Report of the World Commission on Dams: An Advocacy for Improved Information Base for Sustainable and Equitable Management of Water and Energy Resources
Dr. Madiodio NIASSE, IUCN (by conference call)

11:15 Panel discussion of lessons learned during the workshop on improving the use of data for decision making toward sustainable development

Question for Session 4 Panel discussion: Based on the technical, scientific, management, and policy successes and barriers encountered in the creation and use of data that have been identified and discussed in this workshop, what actions might be taken to improve the creation and use of data for sustainable decision making regarding the Senegal River basin?

11:30 *Summary of meeting by rapporteur*
Dr. Paul UHLIR, National Research Council

12:15 *Closing remarks by workshop cochairs*
Dr. Abdoulaye GAYE and Dr. William JOBIN

12:30 ***End of meeting — lunch***

Appendix B

List of Workshop Participants

Workshop Cochairs

Dr. Abdoulaye GAYE (ecology and agronomy), Chair of the Senegal National Committee for CODATA, Dakar*
e-mail: agaye@primature.sn

Dr. William JOBIN (public health and environmental engineering), Blue Nile Associates, Dolores, CO*
e-mail: snail@mail.fone.net

Workshop Rapporteur

Paul F. UHLIR, J.D. (information law and policy, international relations), Director of U.S. National Committee for CODATA, National Academy of Sciences, Washington, DC*
e-mail: puhlir@nas.edu

U.S. Participants

Mr. Tinomutenda Tamuka MAGADZIRE (GIS and remote sensing), University of California at Santa Barbara, Santa Barbara, CA
e-mail: tamuka@geog.ucsb.edu

Ms. Kristine McELWEE (oceanic and atmospheric sciences), National Ocean Services Pacific Services Center
e-mail: Kris.McElwee@noaa.gov

---

* = Members of the organizing committee

Prof. William PARTON (ecology and agronomy), Natural Resources Ecology Laboratory, Colorado State University, Fort Collins, CO*
e-mail: billp@nrel.colostate.edu

Prof. William SPRIGG (atmospheric sciences), University of Arizona, Tucson, AZ*
e-mail: wsprigg@u.arizona.edu

Dr. Wassila THIAW (hydrology and remote sensing), Climate Prediction Center, National Centers for Environmental Prediction, Washington, DC
e-mail: Wassila.Thiaw@noaa.gov

Dr. Larry L. TIESZEN (remote sensing and international relations), Deputy Manager, International Programs, EROS Data Center, Sioux Falls, SD*
e-mail: tieszen@usgs.gov

Prof. Aaron WOLF (hydrology and international relations), Oregon State University, Corvallis, OR (by conference call)
e-mail: wolfa@geo.orst.edu

U.S. National Committee for CODATA Staff

Ms. Julie ESANU (international relations), Program Officer, National Academy of Sciences, Washington, DC
e-mail: jesanu@nas.edu

Ms. Pamela GAMBLE, Project Assistant, National Academy of Sciences, Washington, DC
e-mail: pgamble@nas.edu

Senegalese Participants

Dr. Oumar Talla DIAW (malacology and epizootiology), Biologist, Laboratoire National de Recherches Vétérinaires, Dakar* (*unable to attend due to illness*)
e-mail: OTDiaw@hotmail.com

Alioune DIENG (agronomy), chercheur, ISRA/BAME
e-mail: adieng@isra.sn or dieng_alioune@hotmail.com

Amadou Moctar DIEYE (environmental information/GIS), Centre de Suivi Ecologique, Dakar
e-mail: dieye@cse.sn

Dr. Dialo DIOP (virology), Secretary General of CODATA Senegal, and Biologist and Physician at the Hopital des Enfants Malades, Albert Royer CHU-FANN, Université Cheikh Anta Diop *
e-mail: dialod@ucad.sn

Dr. Mbarack DIOP (environmental studies), TROPICA, Dakar
e-mail: tropica@sentoo.sn

Dr. Amadou MBAYE, Programme Espoir (Richard Toll)
e-mail: ambaye@sentoo.sn

Mr. Malick NDIAYE, Ingénieur en Intelligence Artificielle, Conseiller Technique Primature, Dakar
e-mail: malick@primature.sn

Dr. Ana NIANG, Tropis Cabinet, Dakar
e-mail: n_awa@hotmail.com

Mr. Cheikh Tidiane SAKHO (civil engineer), Chargé d'Etudes, Délégation à l'Informatique
e-mail: acorre@telecomplus.sn

His Excellency Fodé SECK, Ministry of Foreign Affairs, African Union, and Senegalese Abroad, Dakar
e-mail: fodeseck@yahoo.sn

Mr. Madiaw SECK (environmental planning and management), Direction de l'Aménagement du Territoire in Dakar and Senegal Representative for the planning of the 2002 World Summit on Sustainable Development in Johannesburg*
e-mail: madiaw.seck@talk21.com

Mr. Assize TOURE (environmental data management and archiving), Centre de Suivi Ecologique, Dakar
e-mail: assize@cse.sn

Mr. Ibrahima Almamy WADE (environmental data management and archiving), Centre de Suivi Ecologique, Dakar
e-mail: almamy.wade@cse.sn

OMVS List of Participants

Mr. Mbacké GUEYE, Directeur du Centre Régional de Documentation de l'OMVS à Saint-Louis
Tel: (221) 961 2388 / 641 2166
e-mail: Mbackegueye@hotmail.com

Mr. Tamsir NDIAYE, Chef du Bureau de l'Observatoire pour l'Environnement
Tel: (221) 822 0668 / 652 6536
e-mail: Ndiayetamsir@hotmail.com

Mr. Malang DIATTA, Expert en Hydrologie, Direction de l'Infrastructure Régionale, OMVS
Tel: (221) 822 0668

Mr. Mody SECK, Informaticien, OMVS
Tel: (221) 823 4530 / 683 6124
e-mail: Mody@seck.net

Mr. Alassane TOURE, Chef du Bureau Archivage, Centre Régional de Documentation de l'OMVS à Saint-Louis

CODATA AFRICA Task Group Members

Mr. Mamadou KANOUTE, Ministère de l'Energie, Dakar
e-mail: makanoute@hotmail.com

Dr. Clement Entsua-MENSAH, Director CSIR-INSTI, Accra
e-mail: cemensah@libr.ug.edu.gh or cemensah@hotmail.com

Dr. Kingsley Oise MOMODU, Chairman CODATA Nigeria, University of Benin, Benin City
e-mail: komomodu@yahoo.co.uk

Other African Participants

Dr. Madiodio NIASSE (hydrology and engineering), Regional Coordinator, IUCN Wetlands and Water Resources Programme, Ouagadougou (by conference call)
e-mail: madiodio.niasse@iucn.org

Mr. Hamdou-Rabby WANE (economics), Centre d'Etudes et de Recherche sur la Population pour le Développement, Bamako
e-mail: wane_baba@yahoo.fr

Other Participants

Dr. Lester CHITSULO (tropical diseases), Disease Research Coordinator–Schistosomiasis, World Health Organization, Geneva
e-mail: chitsulol@who.ch

Mr. Donald CLARK, Mission Director, Senegal Office, U.S. Agency for International Development, Dakar
e-mail: donclark@usaid.gov

Mr. François FAYE, Ag/NRM, Senegal Office, U.S. Agency for International Development, Dakar

Dr. Per Bøgelund HANSEN, Chief Engineer, DHI Water and Environment, Denmark
e-mail: pbh@dhi.dk

Mr. Peter TRENCHARD, Ag/NRM Advisor, Senegal Office, U.S. Agency for International Development, Dakar
e-mail: ptrenchard@usaid.gov

Appendix C

Contact Information on Selected Scientific Data Sources

African Development Bank
Rue Joseph Anoma
01 BP 1387
Abidjan 01, Côte d'Ivoire
Tel: 225 20.20.44.44
Fax: 225 20.20.49.59
E-mail: afdb@afdb.org
Web site: http://www.afdb.org/

AGRHYMET Regional Center
BP 11011
Niamey, Niger
Tel: (227) 73.31.16 / 73.24.36
Fax: (227) 73.24.35
Telex: 5448 NI
E-mail: admin@sahel.agrhymet.ne
Web site: http://www.agrhymet.ne/cilssaccueil.htm

Barrage de Diama
BP 396
Saint-Louis, Senegal
Tel: 221 961 16 55
Fax: 221 961 16 31

Centre de Suivi Ecologique
Rue Léon G. Damas, Fann Résidence
BP 15532
Dakar-Fann, Senegal
Tel: 221 8258066/8258067
Fax: 221 8258168
E-mail: niang@cse.sn
Web site: http://www.cse.sn

Comité Inter-Etats de Lutte contre la Sécheresse au Sahel (CILSS)
03 LP 7049
Ouagadougou 03, Burkina Faso
Tel: 226 30 67 58
Fax: 226 30 67 57
E-mail: cilss@fasonet.bf
Web site: http://www.cilssnet.org/

Centre De Recherches Océanographiques Dakar-Thiaroye (CRODT)
BP 2241 Km 10,
Route de Rufisque
Dakar, Senegal
Tel: 221 34-05-3
Fax: 221 34-27-92
Web site: http://www.orst.edu/dept/ip/irn/senegal/Crodt.htm

Ecole Inter-Etats des Sciences et Medecine Vétérinaires De Dakar
BP 5077
Dakar, Senegal
Tel: 221 865 10 08
Fax: (221) 825 42 83
E-mail: mariamd@eismv.refer.sn
Web site: http://www.refer.sn/eismv/eismv.htm

EIS Africa
CSIR-Environmentek, Room N162,
Bldg 33
PO Box 395,
Pretoria 0001, South Africa
Tel: 27-12-349 1068
Fax: 27-12-349 2080
E-mail: eis.program@mweb.co.za
Web site: http://www.eis-africa.org

ENDA Third World
4 & 5 rue Kléber BP 3370
Dakar, Senegal
Tel: 221 821.60.27 / 22.42.29
Fax: 221 822.26.95
E-mail : enda@enda.sn
Web site: http://www.enda.sn/english/index.htm

European Centre for Medium-Range Weather Forecasts
Shinfield Park
Reading, United Kingdom
RG2 9AX
Tel: 44 118 949 9000
Fax: 44 118 986 9450
E-mail: ECMWF-Director@ecmwf.int
Web site: http://www.ecmwf.int/

Global Environment Facility Secretariat
1818 H Street, NW
Washington, DC 20433 USA
Tel: 202-473-0508
Fax: 202-522-3240/3245
E-mail: secretariatofgef@worldbank.org
Web site: http://www.gefweb.org/

Institut du Sahel
BP 1530
Bamako, Mali
Tel: 223 22 21 48/223 22 30 43
Fax: 223 22 23 37
E-mail: idriss@agrosoc.insah.ml
Web site: http://www.insah.org/start_insah.htm

Institut Sénégalais de Recherches Agricoles (ISRA)
PO Box 3120
Dakar, Senegal
Tel: +221 8322420
Fax: +221 8322427
Web site: http://www.refer.fr/sngal_ct/rec/isra/isra.htm

Institute for Development Anthropology
99 Collier Street, Suite 302
PO Box 2207
Binghamton, NY 13902 USA
Tel (607)-772-6244
Fax (607)-773-8993
Web site: http://www.developmentanthropology.org/

Intergovernmental Panel for Climate Change Secretariat
c/o World Meteorological Organization
7bis Avenue de la Paix, C.P. 2300, CH-1211
Geneva 2, Switzerland
Tel: 41-22-730-8208
Fax: +41-22-730-8025
E-mail : ipcc_sec@gateway.wmo.ch
Web site: http://www.ipcc.ch/

International Research Institute for Climate Prediction
61 Rt. 9W
PO Box 1000
Palisades, NY 10964-8000 USA
Tel: 914-680-4468
Fax: 914-680-4866
E-mail: info@iri.columbia.edu
Web site: http://iri.Columbia.edu

IRD Sénégal (ex Orstom)
BP 1386
Dakar, Senegal
Tel: 221 849.35.35
Fax: 221 832.43.07
E-mail: info@ird.sn
Web site: http://www.ird.sn/

NOAA/National Weather Service
National Centers for Environmental Prediction
Climate Prediction Center African Desk
5200 Auth Road
Camp Springs, MD 20746 USA
Web site: http://www.cpc.ncep.noaa.gov/products/african_desk/

Organisation pour la Mise en Valeur du Fleuve Gambie
13, Passage Leblanc, BP 2353
Dakar, Senegal
Tel: 221 22 31 59
Fax: 221 22 59 26

OMVS Haut-Commissariat
46, Rue Carnot, BP 3152
Dakar, Senegal
Telex: 51 670 ORMIVAF SG
Tel: 221 823-45-30
Fax: 221 822-01-63
Web site: http://www.omvs-hc.org/

OMVS Direction Technique
5, Place de l'Indépendance (2ème Étage)
Tel: 221 822-06-68
Fax: 221 823-47-62
E-mail: omvsdept@metissacana.sn

OMVS Centre Régional de Documentation
Rue Duret - Sud, BP 383
Saint-Louis, Senegal
No Web site available

Observatoire du Sahara et du Sahel (OSS)
Boulevard de l'Environnement BP 31,
1080 Tunis Cedex, Tunisia
Tel: 216 - 71 - 80 65 22
Tel: 216 - 71 - 80 68 91
Fax. 216 - 71 - 80 73 10
Web site: http://www.unesco.org/oss/

Société d'Aménagement et d'Exploitation du Delta du Fleuve Sénégal (SAED)
Route de Khor Sor
BP 74
Saint-Louis, Senegal
Tel: 221 961 13 80
Fax: 221 961 14 63
E-mail: saed@metissacana.sn
No Web site available

Société de Gestion et d'Exploitation de Diama (SOGED)
BP 28
Rosso, Mauritania
Tel: 222 569-129
Fax: 222 569-205
No Web site available

Société de Gestion de l'Énergie de Manantali (SOGEM)
Rue 335 X 336 Quartier Hippodrome, BP 4015
Bamako, Mali
Tel: 223 21-03-92 /21-32-84
Fax: 223 21-11-22
No Web site available

Special Programme for Research & Training in Tropical Diseases (TDR)
World Health Organization
1211 Geneva 27
Switzerland
Tel: 41 22 791 3725
Fax: 41 22 791 4854
E-mail: tdr@who.int
Web site: http://www.who.int/tdr/

Université Gaston Berger de Saint-Louis
BP 234
Saint-Louis, Senegal
Tel: 221 961 19 06 /961 17 68
Fax: 221 961 18 84
Telex: 75 128 UNIV. Sl/SG
Web site: http://www.ugb.sn/

Université Cheikh Anta Diop
BP 5005
Dakar-Fann, Senegal
Tel: 221 825 75 28
Fax: 221 825 37 24
E-mail: info@ucad.sn
Web site: http://www.ucad.sn/

U.S. Agency for International Development (Guinea Office)
Quartier Cameroun, Corniche Nord
US Embassy, BP 603
Conakry, Guinea
Tel: 224-41-2163, -2502, -2029
Fax: 224-41-1985
Web site: http://www.usaid.gov/gn/

U.S. Agency for International Development (Mali Office)
Immeuble Dotembougou
Rue Raymond Poincarre & Rue 319
Quartier du Fleuve / BP 34
Bamako, Mali
Tel: 223-22-3602
Fax: 223-22-3933
Web site: http://www.usaid.gov/ml/

U.S. Agency for International Development (Senegal Office)
BP 49
2130 Avenue Jean XXIII and Rue Kleber
Dakar, Senegal
Tel: 221-823-1885, 0242, 5880, 2848
Fax: 221-823-6155

U.S. Geological Survey
EROS Data Center
47914 252nd Street
Sioux Falls, SD 57198-0001 USA
Tel: 800-252-4547
Fax: 605-594-6151
Web site: http://edc.usgs.gov

World Conservation Union (IUCN)
Senegal Country Office
BP 3215
Dakar, Senegal
Tel: 221 824-0545
Fax: 221 824-9246
E-mail: iucnsn@sentoo.sn
Web site: http://www.iucn.org/

Appendix D

Acronyms and Initialisms

ABN	Autorité du Bassin du Niger
AGRHYMET	Regional Center for Training in Agriculture, Hydrology, and Meteorology
AMSU	Advanced Microwave Sounding Unit
AVHRR	Advanced Very High Resolution Radiometer
CILSS	Comité Inter-Etats de Lutte contre la Sécheresse au Sahel
CODATA	Committee on Data for Science and Technology
CONSERE	Conseil Supérieur des Ressources Naturelles et de l'Environnement
CRODT	Centre de Recherches Océanographiques Dakar-Thiaroye
CSE	Centre de Suivi Ecologique
EIS	environmental information system
ENDA	Environment and Development Action in the Third World
EROS	Earth Resources Observation Systems
FEWS NET	Famine Early Warning System Network
GEF	Global Environment Facility
GIS	geographic information system
GOES	Geostationary Operational Environmental Satellite
GRF	Global River Floodplains project
GTS	Global Telecommunications System
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit

ICSU	International Council for Science
IRD	Institut Français de Recherche pour le Développement
ISRA	Institut Sénégalais de Recherches Agricoles
IUCN	World Conservation Union
MODIS	Moderate-resolution Imaging Spectrometer
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
OMVG	Organisation pour la Mise en Valeur du Fleuve Gambie
OMVS	Organisation pour la Mise en Valeur du Fleuve Sénégal
PASIE	Programme d'Atténuation et de Suivi des Impacts sur l'Environnement de l'OMVS
RFE	rainfall estimation
S&T	scientific and technical
SAED	Société d'Aménagement et d'Exploitation du Delta du Fleuve Sénégal
SFM	streamflow model
SOGED	Société de Gestion et d'Exploitation de Diama
SOGEM	Société de Gestion de l'Energie de Manantali
SONADER	Société Nationale de Développement Rural
SPOT	Système Probatoire pour l'Observation de la Terre
SRB	Senegal River basin
SSM/I	Special Sensor Microwave/Imager
SST	sea surface temperature
STI	scientific and technical information
TDR	Special Programme for Research and Training in Tropical Diseases
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
USNC	United States National Committee
WCD	World Commission on Dams
WHO	World Health Organization