# NOTE SUR
# LE RWANDA
# ET
# L'HYDROLOGIE ORSTOM

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rédigée par A. GIODA

à l'occasion de la visite du
Président de la République Rwandaise
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Tirage de la note

I - Actions passées des hydrologues au Rwanda

Essentiellement un soutien pour contrôler et publier les données hydrologiques sur la période 1950 - 1970. Un gros travail mais déjà ancien.

II - Actions ponctuelles et très récentes

Dans deux directions mais sans doute complémentaires.

II.1- 1987 : Mission de Jacques COLOMBANI sur la pré-formulation/faisabilité de la construction de microcentrales hydro-électriques (cf. annexes).

II.2 - 1989 : Mission PNUD par Jean-Marie FRITSCH pour le renforcement du Service hydrologique et de réseau hydrométrique.

III - Actions porteuses d'avenir

III.1 - Le travail d'Eric ROOSE sur la formation au Rwanda de spécialistes de la lutte anti-érosive en liaison avec l'ISAR. (Institut Scientifique Agronomique Rwandais) (cf. annexes).

III.2 - Dans la sous-région, le développement sur financement MRT français de la télétransmission de données sur le fleuve Congo et son bassin (8 stations satellitaires METEOSAT en commande).

III.3 - Le fait que la mission PNUD (précédemment citée) s'insère dans un travail portant sur l'ensemble du bassin du Nil (9 pays concernés dont le Rwanda) et là, aussi, l'espoir d'une meilleure gestion de la ressource en eau par la télétransmission satellitaire.

CONCLUSION

De façon plus générale, et ce sera ma conclusion, l'hydrologie à l'ORSTOM oriente son action vers la formation soit dans les pays africains soit ici à Montpellier (cf stage "Technologies Nouvelles" prochaine session octobre - novembre 1990).
Actuellement d'ailleurs, il y a la session de printemps.

Après la Visite :

- Intérêt manifeste du Président pour la télétransmission satellitaire.
- Dépliant du stage "Technologie Nouvelles" fourni à chaque membre de la délégation.

JEAN-MARIE FRITSCH
(1989)

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# DOCUMENTS SUR LE

# RWANDA

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## Mission PNUD sur

## le bassin du NIL

An attempt is made by the present Hydromet/WMO Project to collect a substantial part of the data with reduced delays, in order to publish a ten-day climatological report.

All hydrological data is manually processed. The Division of Hydrological publish year books including the basic hydrological information (daily water levels or discharges) and some first level analysis parameters (isohyetal map for the whole country, average yearly rainfall and water balance for each watershed and others). The 1985 year book is the last one published (June 1988).

The Meteorogical Service operates the stations installed and calibrated during the Hydromet Project. Subsequent hydrological data are published in the meteorological year-book. Last data published is found in the 1987 yearbook.

The data are archived in hard copies. Several projects of computerized data processing and analysis are on-going or are scheduled to start in a near future (see a.5) below).

a.4) Quantity and quality of the data available

The recording stations in operation at the present time break down as follows :

| | Division of Hydrology<br>number of stations in 1985 year book | Meteorological Service<br>number of stations in 1987 year book |
|---|---|---|
| Daily rainfall and temperatures | | 115 |
| All synoptic station data | | 5 |
| Water levels | 19 | 7 |
| Water levels and discharges | 21 | 5 |

The climatological and meteorological data are claimed to be of good quality, while the hydrologists complain about the shortage f field equipment, (mainly streamflow gauging equipment) and about the eakness of the Division of Hydrology in terms of staff (only 8 technicians for field operation and hand data processing).This situation does not allow proper survey conditions and subsequent collection of accurate data.

a.5) Past assistance

ORSTOM Cooperation Project : processed an published all data for the period 1950-1970

Belgian assistance Project (Royal Belgium Institute): all meteorological and hydrological data up to 1981 have been quality controlled and put on computer storage media. These data will be made available to the Government in the scope of the future Belgian assistance project to Meteorological Service (see below)

a.6) On-going projects :

UNDP financed Agromet Project With Meteorological Service Ref

software be compatible (if not the same), in order to allow proper and easy data communication and exchange at national level between Meteorology and Hydrology. This recommendation applies also to the Belgium bi-lateral assistance project to Department of Meteorology.

From the above information, it appears that there may be some overlapping of assistance in given areas, in particular data processing and data bank systems, while some other areas of primary interest such as data collection, stream gauging and, generally speaking network operation and maintenance are completely neglected. It would be the interest of all parties and, in the first place the national technical departments concerned, to integrate the technical assistance offered to Rwanda, in order to develop the comprehensive capability required by its technical departments, in particular, to meet the needs of a regional programme of the Nile basin water resources development.

# R W A N D A

## 1. AGRICULTURE AND DROUGHT

Rwanda is a small but heavily populated country where the population density is more than 171 per square kilometer. Agriculture makes up about half of the GDP and three-fourths of the export earnings (coffee alone accounts for about 60 percent).

The main food crops are bananas, sorghum, sweet potato, Irish potato, manioc, maize, groundnuts, peas, fruits, rice, soybeans, etc. The main cash crops are coffee, tea, pyrethrum, and sugarcane. Some 1.059 million hectares are planted to cash crops. Coffee is the main export. In the past Rwanda exported groundnuts, rice and soybeans. However, these crops are now totally consumed domestically. The main food imports are meat, fish, oilseeds, rice and milk. Value of the food exported exceeds that of the food imported. The Government is trying to reduce rice imports by increasing local production.

All arable land is cultivated and the farms are mostly in the 1 to 3 hectares range. Rwanda does not have farming estates. Usually two crops per year are planted.

Droughts had not been a serious problem in the past. However, reecently the country has been experiencing some irregularities in the onset of rains. Last year, when there was very little precipitation in March and even less in April yields were reduced. Government authorities believe that the 1984 crop shortfalls relative to 1983 will prove to be 45,361 tons for beans, 17,626 for peas and 72,400 for sorghum.

## 2. AGROMET DATA BASE

The meteorological service of Rwanda was established in 1963. Other institutions, primarily the Ministry of Agriculture, operated meteorological stations before then. Though many of these stations were turned over to the meteorological service in 1973, those institutions still operate their own meteorological stations.

### 2.1 Network and Data

The meteorological service operates 5 synoptic stations, 30 principal climatological stations and 135 raingauge stations. In addition to the parameters which are common in climatological stations, the principal climatological stations are equipped to make observations of soil temperature at 10, 20, 50 and 100 cm depths as well as the hours of sunshine. Evaporation is measured by either Class A pan or Piche evaporimeters (but not both). The 5 synoptic and 2 of the climatological stations are equipped with recording rain gauges. One climatological station at the university is equipped to make radiation intensity observations.

The first station was established in 1907. Some 27 stations are 40 years or older. The average record length of the stations is 20 years or slightly longer.

The Institute of Agronomic Sciences of Rwanda (ISAR) is a new institution with a network of 11 climatological stations. These stations serve agricultural purposes though they are not exactly agromet stations, i.e. they do not make phenological or soil moisture observations. All of them, however, are equipped with Gunn Bellanis and one with a lysimeter.

The agromet unit of the Ministry of Agriculture is another institution with a network of stations. The network is composed of 14 stations measuring temperature and precipitation. Instrumentation has been ordered to upgrade 10 of the above stations with soil thermometers at 10 and 20 cm depths, Campbell-Stokes sunshine recorders, thermographs, hygrographs, Piche evaporimeters and Class A pans. Wind, soil moisture and radiation measurement instruments, however, will be lacking.

The ISAR stations were set up in 1949. Those in the agromet unit of the Ministry of Agriculture were established according to needs and at different dates. However, most have 10 to 15 years of records.

## 2.2 Analysis and Bulletin

The meteorological service publishes the Annual Climatological Bulletin on a regular basis. The last one published covers the 1981 records. There are a number of irregular publications. Chief among them is one dealing with precipitation intensity, one dealing with monthly and annual precipitation and one dealing with aeronautical climatology.

There is no agromet or precipitation bulletin. It takes about 10 days for the records of most stations to reach the Headquarters. However, about 10 stations can phone the data in if a timely precipitation bulletin project is launched.

A major undertaking in data compilation and analysis has been taken over by the Royal Belgian Institute. In this project, all of the raw meteorological records, including those belonging to the network, of the Ministry of Agriculture, are copied and transferred onto cassettes. The final objective of this project is to prepare the climatology of Rwanda.

ISAR publishes it's records anually. The agromet unit of the Ministry of Ariculture is currently processing it's records for publication.

## 3. CURRENT LIMITATIONS

Three institutions, namely the meteorological service, ISAR and the agromet unit of the Ministry of Agriculture operate networks and collect data useful for agricultural purposes. Yet, there is no co-ordinating committee among them. The exchange of data among the three is possible but not carried out on a regular basis.

High population density and the lack of uncultivated arable land is a major limitation. The average farm size today is less than 40 percent of what it was in 1953. With an increasing population and pressure on the land, fallowing practices have diminished considerably and soil conservation measures are becoming even more important.

About 95 percent of the people derive income from the agriculture sector. Agriculture provided 45 percent of government revenue, yet receives only 12 percent of public expenditures. Probably as a result, while population is increasing at a rate of 2.6 percent, the annual growth in agriculture has been about 1.5 percent.

## 4. PROSPECTS AND POTENTIALS

Rwanda is blessed with good soil and climate. The soil is still fertile despite some erosion. The climate allows growing of two crops annually. The considerable topographic variations have led to sizeable temperature variations and, thus, possibilities of growing quite differeent types of crops.

In order to maintain an adequate food supply for a growing population without increasing pressure on the land, the yields have to increase by 3 percent annually. The yields of export crops should increase at an annual rate of 5 percent in order to supply the necessary foreign exchange.

To increase yields, the Government promotes regionalization of crop production. It encourages growing maize, potato and wheat instead of bananas on the highlands. Groundnuts, soybeans, sorghum, beans and bananas are recommended for the midlands. Improvements in seeds and the avaiability of fertilizer are chief among the governments endeavors to increease yields.

Irrigation potential allows increasing cropping by 15 percent. Irrigation is largely limited to rice. Even sugarcane is grown without irrigation and in swamplands.

In order to estimate the current food situation, the Government has a rather efficient service of field sampling of yields and extrapolation to regional production.

The country has the equivalent of four Class I agrometeorologists, two in the Ministry of Agriculture, one in ISAR and one at the university. The most significant agromet work is going on in ISAR where the yields of major crops are being related to 10-day precipitation and temperature data.

## 5. RECOMMENDATIONS

In order for the Meteorological Services of Rwanda to improve their capabilities for services in the area of agromet in general, and drought in particular, the following are recommended:

5.1 Improved co-operation and co-ordination - including routine exchange of data - should be established among the three major services collecting and analyzing meteorological data.

5.2 Rwanda should send three people on fellowships for training as Class I, Class II and Class III agrometeorologists.

5.3 All of the 10 stations in the agromet unit of the Ministry of Agriculture should be equipped with anemometers, Class A pans, neutron probes and Robitzsch pyranometers.

5.4 The above stations should be provided with forms and instructions for making phenological observations and recording of the yields of the major crops in the vicinity of the stations.

5.5 The past meteorological records of Rwanda should be analyzed to establish the drought climatology of the country.

5.6 The existing yield and weather records should be analyzed in order to develop mathematical relationships which can be used to estimate the impact of precipitation deficiencies and/or anomalies on crop yields more quantitatively.

5.7 A 10-day precipitation bulletin, giving various precipitation parameters relative to normals, shold be published and distributed to agricultural authorities on a routine basis.

5.8 A suitable drought index should be chosen for routine drought monitoring to be included in the 10-day bulletin.

# R W A N D A

## 1. STATION NETWORK

1.1 There is no unified service for operational hydrology, meteorology and agrometeorology in Rwanda. The Meteorological observational station network consists of:

- Five synoptic stations which, except for Kigali Airport with a 24-hour schedule, run a 12-hour program;
- Four principal climatological stations;
- 135 rainfall-only stations;
- One radiation station.

Measurements at the principal climatic stations include sunshine, evaporation and soil temperature at 10, 20, 50 and 100 cms. Some of the rainfall stations have about 70 years of data but the average record length is about 30 years. The synoptic stations have an average of 15 years of data - the oldest one was opened in 1961.

1.2 The first hydrological station was established in 1948 for the development of dams for hydroelectric power and for the swampy areas of the country. In 1950 the first Hydrological Year Book containing data for 10 stations was published. At present there are 28 stations, of which 21 are located at lake edges and only take water level measurements. In addition there are 8 hydrological stations that belong to the HYDROMET Survey Regional Project.

1.3 In 1972 the Hydrology Division in collaboration with ORSTOM processed and published all hydrological data for the period 1950-1970; and since that time year books have been regularly published - the last one was for 1983.

1.4 In the past most agrometeorological activities were carried out by ISAR, which, as far back as 1949 had 11 climatological stations that it designated as agrometeorological. But to turn these stations into true agromet stations, soil moisture and phenological observations would need to be made. Over the years the Ministry of Agriculture has established 14 "special purpose" agricultural stations. These stations have an average of 10 to 15 years of data. Ten out of the 14 stations will have additional instrumentation which will upgrade them to agroclimatic status. Some of the equipment has already been procured but still need wind, radiation and soil moisture equipment. ISAR has been putting out annual bulletins which contain rainfall, air temperature, humidity, sun hours and soil temperature - the last such publication was for 1978. The Agrometeorological Section of the Department of Meteorology does not put out any publications although it does process some of the agrometeorological parameters.

1.5 Under a special project, Belgium has computer processed all available meteorological, hydrological and agromet data from Rwanda up to 1981. The clean data is now on cassettes.

## 2. DATA FLOW AND QUALITY CONTROL

2.1 Meteorological data is transmitted by SSBs to Kigali Airport in real-time from the 5 synoptic stations. At the airport the data is manually quality controlled and used to prepare aviation forecasts and briefings for

pilots. The Meteorological Department does not provide any public forecasts. The data is also relayed via AFTN to the RTH in Nairobi for onward injection into the GTS.

2.2 Hydrological data is transmitted in delayed mode; the data is posted after the end of the month and takes about 10 days to reach the headoffice in Kigali. In addition the Hydrology Division has a technician brigade which it sometimes uses for data collection. Two Class III meteorologists make initial scrutiny of the data for the 8 HYDROMET Survey stations before forwarding it to the project's headoffice in Entebbe for further processing. The other hydrological data is manually processed and published. The Division has not started transcribing the data on to a computer carrier.

2.3 The Climatology and Data processing Sections at the Meteorological Department headoffice transcribes various daily and 3-hourly values from the synoptic registers on to summary forms and quality controls the data. Rainfall data is also quality controlled and summarized on special forms. These forms are later used in publication of the data. Until now only monthly values of the synoptic elements, rainfall and associated derived parameters are being published. The daily values are simply archived as hard copies. The quality control of data is up to data but, because of lack of funds, publication lags behind - the last Annual Climate Bulletin is for 1981.

## 3. DATA PROCESSING FACILITIES AND PERSONNEL

3.1 Some computing capability exists in Kigali. The Government Statistics Department has an IBM mainframe computer which was procured specifically for the 1978 population census. The Statistics Department also has several NCR microprocessors. An NCR Computer Bureau operates in Kigali. NCR is the only computer company with representation in Rwanda; IBM is not represented.

3.2 For the quality control of meteorological and hydrological data, hand calculators are used. Except for the computerization exercise carried out under the Belgian project referred to above, the Meteorological and Hydrological Divisions have not made attempts to computerize their data processing. All data is archived as hard copies.

3.3 The Meteorological Department has only one officer who has had exposure to computers while on a 2-year climate course in Oran. He can code programs in FORTRAN. The Hydrology Division does not have a person with computer know-how.

## 4. OBSERVATIONS AND RECOMMENDATIONS

4.1 Under the Belgian project all meteorological and hydrological data up to 1981 has been quality controlled and put on computer carrier cassettes. The project had its own objectives for processing the data but the drought project, nevertheless, can benefit from the efforts. It is recommended that the Meteorological and Hydrological Divisions try to obtain copies of the processed data with complete documentation of the files.

4.2 To facilitate future agromet, hydrological and climate data processing and the transfer to computer carrier, a microprocessor system is recommended. The system should include:

- 1 microprocessor of 128 kb of CPU memory together with monitor and keyboard;
- 1 dual diskette drive;
- 1 fixed hard disk of at least 10 mb capacity;
- 1 matrix printer;
- 1 digitizer;
- power stabilizer and air conditioner.

In addition to the above system, for data entry functions, 2 stripped down versions of the above microprocessor are also recommended. These 2 intelligent data capture terminals should consists of:

- microprocessor of 64 kb of CPU memory with monitor and keyboard;
- single diskette drive;
- small printers;
- power stabilizer.

Outputs from these 2 small micros would be further processed on the larger microprocessor system.

4.3 The placement of the 3 systems within the 2 divisions separately located should be discussed and agreed upon by the concerned parties; but it is suggested that the Meteorological Department and the Hydrology Division should each have one intelligent data entry terminals.

4.4 Because at the moment the departments/divisions do not have anybody who has formally been trained in data processing and/or computer programming, the following training fellowships are recommended:

- 1 Class I, 12 months, DP/computer programming;
- 1 Class II, 6 months, data processing;
- 1 Class I, 24 months, climatology;
- 1 Class II, 12 months, climatology;
- 1 Class II (with electronic diploma), 3 months, computer maintenance.

The Class I computer programmer and technician should come from the department/division in which the larger microprocessor will be located.

4.5 There are numerous transcriptions being done in the course of data quality control and publication preparation. There is a need, therefore, to look at the processing procedures again and design new data recording forms. Short term consultant assistance in this area is, therefore, recommended. Such assistance could be provided when the microprocessors systems are being installed; so that the expert could also design and implement a complete data processing system.

4.6 The present filing arrangements in the Meteorological Department of original data returns and other intermediary forms need a lot of improvements. While the mission appreciates the space shortage problem, it feels that, with proper filing cabinets, data documents can have more respectable accommodation.

4.7 The Services are encouraged to develop numeric station identifiers for the non-synoptic observation stations. The present alphabetic identifiers (station names) are more computer time consuming.

# R W A N D A

## 1. ASPECTS GENERAUX

Ce petit pays montagneux (26.338 km²) possède la plus forte densité de population en Afrique (3.724.000 habitants en 1971) est situé très peu au Sud de l'équateur.

On distingue 3 bassins principaux, celui du lac Kivu, de la Nyabarongo, de la Kagera.

Ce pays a participé au projet de l'OMM RAF/73/001 "Etudes hydrométéorologiques des bassins des lacs Victoria, Kyoga, Mobutu Sese Seko" dont le siège est à Entebbe.

## 2. RESEAUX ET SERVICE

Personnel et moyens insuffisants. Le nombre de jaugeages effectués est également très insuffisant et l'étalonnage des stations est souvent inexistant.

### 2.1 Personnel

Le Service hydrologique comprend 3 hydrologues, 3 techniciens, 1 météo Classe I, 1 météo Classe III et 2 météo Classe IV.

### 2.2 Réseaux

36 stations hydrologiques dont 8 installées dans le cadre du projet OMM (4 avec mesure de débit), 2 stations climatologiques et un bassin représentatif.

Ce réseau est insuffisant et devrait être mieux exploité.

### 2.3 Maintenance

Insuffisante.

### 2.4 Collecte des données

A organiser. Actuellement la collecte se fait par la poste.

### 2.5 Formation

Besoins: 2 Classe I ou II en hydrologie,
2 Classe III en hydrologie.

## 3. TRAITEMENT DES DONNEES

### 3.1 Contrôle

Le fait à l'aide de calculatrice de poche. Cependant il est a reprendre. L'ORSTOM a contrôle et publié les données de 1950-70. Depuis 1981 un pso et belgeoa permes le contrôle des données et leur report sur cassettes

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4. POINTS CRITIQUES ET LIMITATIONS

Manque de moyens et de crédit.

5. PERSPECTIVES

Le potentiel hydroélectrique et les perspectives d'irrigation imposent de développer le Service hydrologique qui devra être en mesure de fournir les données indispensables à ce développement.

6. BESOINS IMMEDIATS. RECOMMANDATIONS

Réseau à reprendre.

Contrôle, collecte, traitement et publication des données.

Estimation des ressources en eau.

## ANNEXES - BIBLIOGRAPHIE SOMMAIRE

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