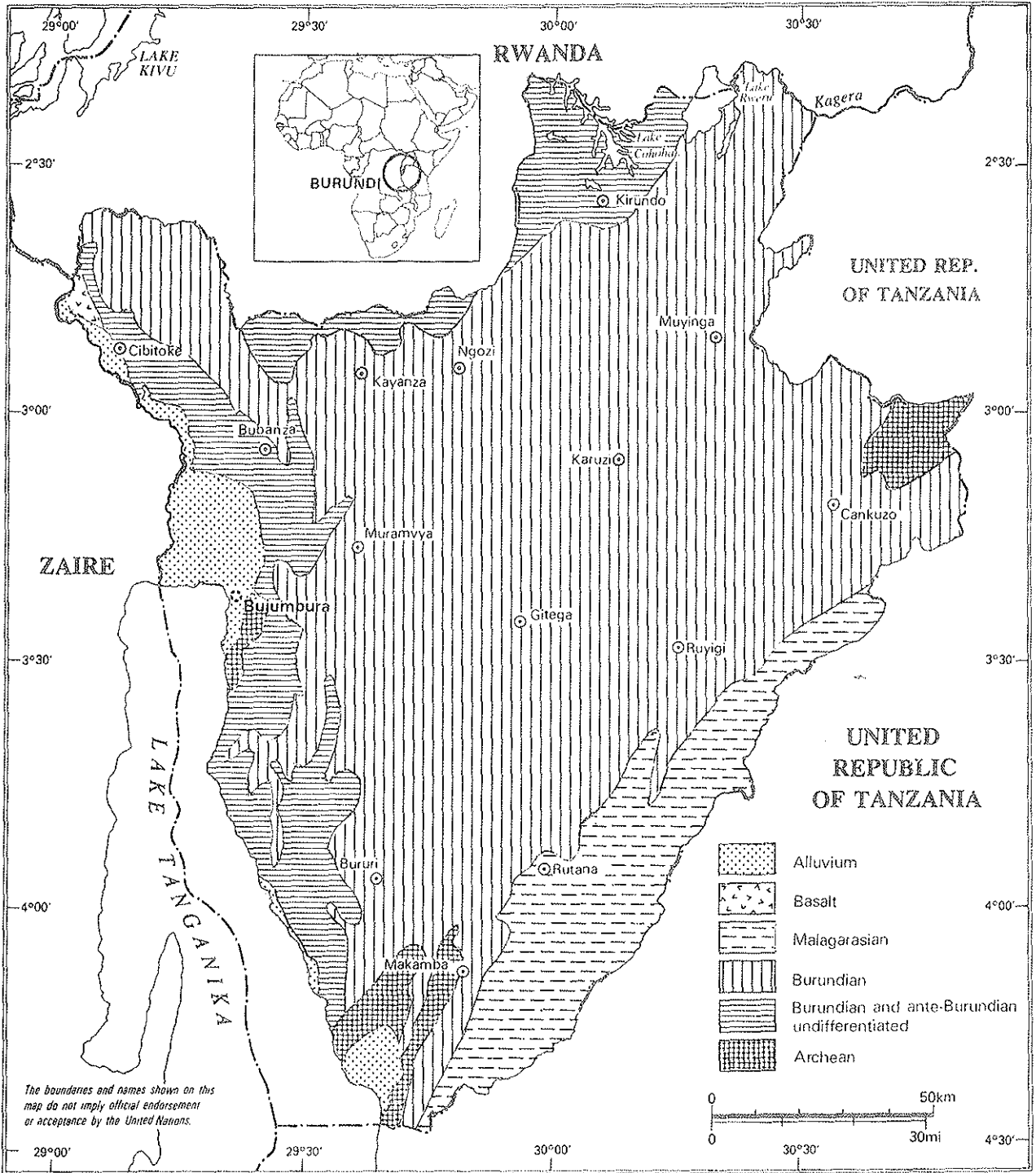


MAP 3. BURUNDI — GEOLOGICAL SKETCH



The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations.

MAP NO. 3484.2 UNITED NATIONS  
MARCH 1989

## BURUNDI

Area: 27,834 km<sup>2</sup>

Population: 4.4 million

### I. BACKGROUND

Burundi is a small country in the centre of Africa on the shores of Lake Tanganyika; it is bordered by Rwanda in the north, Zaire in the west and Tanzania in the east.

By virtue of its high altitude Burundi belongs to the Africa of the high plateaus. Most of the country lies between 1,500 and 2,000 m above sea level. The highest point, Mt. Heha, is 2,670 m. The country is crossed from north to south in its western part by a mountain ridge - the watershed between the Zaire and the Nile.

The lowest region, the Ruzizi plain, north of Lake Tanganyika, lies at an altitude of about 800 m. With the exception of this plain, which is also known as the Imbo plain and is a northwards extension of Lake Tanganyika and of the eastern depression (the Mosso) drained by the Malagarazi River, Burundi is a mountainous country. It is divided into five different topographical zones. These are, from west to east:

- The Imbo plain: The altitude is generally between 774 and 1,000 m, and this plain is in fact a graben containing the Ruzizi River;
- The Zaire-Nile watershed: This is a dissymmetric mountainous area, with the western slope steeper than the eastern slope. It lies between 2,000 and 2,670 m above sea level. This area is scored by a dense hydrographic system with torrential watercourses which have dug deep steep-sided valleys;
- The central plateau: Consisting of hills between 1,500 m and 2,000 m in altitude. These hills are generally rounded and dome-shaped, separated by wide flat-bottomed and often marshy valleys. They constitute the "mamelon" landscape typical of the centre of the country;
- The north-east depressions: Low areas with wide marshy valleys and small lakes, the most important of which are Lake Cohoha and Lake Rweru;
- The Mosso depression: Between 1,200 and 1,400 m above sea level and drained by the Malagarazi.

### Climate

Owing to its geographical situation, Burundi has a wet tropical climate with two main seasons: a rainy season and a dry season. The rainfall distribution depends on relief, but the rainy season has two very clear high points in November and April, with little rainfall in December-January.

In terms of average annual rainfall (in months) and the number of rainy months and days, the following regions can be distinguished:

- The regions with heavy rainfall (1,600 - 2,000 mm): These regions are in the highest part of Burundi; the Zaire-Nile watershed, where the altitude is generally above 2,000 m. This region has nine rainy months in the year (from September to May). November and April have 21 to 28 rainy days a month; the other seven rainy months have 15 rainy days a month.
- The regions with average rainfall (annual average: 1,200 mm): These regions are the central plateaus and the western slopes of the Zaire-Nile watershed. The altitude varies between 1,600 and 2,000 m; these regions have a rainy season of eight months (October to May) but receive no rainfall in the dry season;
- The regions with a little rainfall (annual average: 900 - 1,200 mm): These regions include a large part of the central plateaus, the Mosso region and the foot of Mirwa. The rainy season lasts seven to eight months (from November to May). The dry season is longer, lasting five to six months;
- The dry regions (annual average below 900 m): These regions include the Ruzizi plain and part of Bugesera (region of Lakes Cohoha and Rweru). There are even some stations in the Ruzizi plain where the annual average is below 700 mm. Rain falls on few days; the monthly total can fall in two or three days. As a general rule these regions have a big water problem, for the heavy evaporation caused by the intense sunshine throughout a long dry season causes the water tables to fall.

In the best-watered regions the coefficient of precipitation variation is small, but it is larger in the poorly-watered and dry regions. As a general rule, the drier the region, the more irregular the rainfall pattern from year to year and month to month.

Three regions can be distinguished in terms of temperature:

- Hot regions: The Imbo plain (alt. 774 to 1,000 m) which has an average annual temperature of 23 °C. It also has intense sunshine (2,444.5 hours in July) which stands in a direct ratio to evaporation;
- Regions of average heat: The low regions (1,000 to 1,300 m) of the Mosso and the northern depressions. They have an annual average temperature of between 23 °C and 30 °C. Here too the sunshine is intense: 1,372.5 hours in July at the Musasa station in the Mosso;
- Relatively cool regions: The central plateaus (alt. 1,500 - 2,000 m) and the Zaire-Nile watershed (alt. over 2,000 m). The average temperature in the central plateaus is a little below 20 °C, while on the Zaire-Nile watershed it is about 15 °C. In these regions the sunshine is relatively less intense than in the lower regions.

Generally speaking, the temperatures vary little throughout the year. The range is below 5 °C.

From the hydrological standpoint, the low regions (Imbo plain, the Mosso), which have intense sunshine, are subject to heavier evaporation than the high regions. The sunshine is probably the decisive factor in the country's hydrology (evaporation of water, fluctuation of water tables). This phenomenon is more intense during the dry season, for the driest months are also the ones with the most hours of sunshine

(peaks in July and August). This phenomenon is also sustained by the fairly high temperatures, especially at the end of the morning, even in the rainy season.

#### Surface water

Burundi has four hydrological regions:

- The Imbo plains;
- The Zaire-Nile watershed;
- The high plateaus;
- The Mosso plains.

The Imbo plains include the whole of the hydrographic basin of the group of direct tributaries of Lake Tanganyika and the Ruzizi basin. The direct tributaries of Lake Tanganyika are: The Mushara, Rwaba, Murembwe, Dama, Ruzibazi, Mugere, Mutimbuzi and Ntahangwe. The average levels of some of these tributaries are given in the following table:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Dama								0.39	0.39	0.39	0.38	0.41
Murembwe	0.87	0.97	0.89	1.00	1.96	0.66	0.53	0.49	0.55	0.52	0.52	0.72
Ntahangwe	0.68		0.76	0.77	0.75	0.65	0.47	0.39	0.55	0.59	0.61	0.70
Nyangwe	0.69	0.50	0.65	0.71	0.60	0.47	0.41	0.37	0.36	0.36	0.34	0.54
Ruzibazi									0.63	0.66	0.64	0.69
Rwaba	0.78	0.67	1.03	1.69	1.31	0.46	0.30	0.28	0.28	0.28	0.25	0.40

Of the 22 rivers of the Ruzizi basin, the main ones are: the Luhwa, Myakagunda, Kaburantwa, Kagunuzi and Mpanda.

All the rivers of Lake Tanganyika and the Ruvubu basin rise in the Zaire-Nile watershed. The main watercourses of the high plateaus are the Ruvubu, Kanyaru and Kagera. The average flow of the Ruvubu is about 11 m<sup>3</sup>/s. The Ruvyironza, one of the tributaries of the Ruvubu, is the southern-most source of the Nile.

The watercourses of the Malagarazi basin (Muyovozi, Mutsindozi and Rumpungu) have a gentle slope. The Malagarazi flows into Lake Tanganyika after a long detour through Tanzania.

In addition to Lake Tanganyika in the west of the country, there are five small lakes in the north: Cohoha, Rweru, Kanzigiri, Rvihinda and Gacamirinda.

## II. GEOLOGY

The following geological formations are found in Burundi:

- "Recent" post-Precambrian sedimentary formations, mainly filling the tectonic trench of the Rift Valley;
- Basaltic rocks of Cenozoic age which outcrop in the extreme north-west of the country;
- Precambrian rocks forming three big systems: the Archaean complex (the oldest), the Burundian and the Malagarasian.

The Archaean complex consists largely of migmatitic and granitic gneiss, with local intercalations of amphibolite and metaquartzite strata. These rocks have undergone very complex tectonic-metamorphic evolution which has generally erased their original mineralogy and structure. (Age: 2,500 million years).

The Burundian is part of the "Kibarian chain" which extends from south of Shaba (Zaire) into Uganda. In Burundi the folded sediments in the Kibarian chain are mainly of pelitic arenaceous type.

The Lower Burundian begins with a large quartzitic formation (Murore) which is in contact with the Archaean basement in the north-east. This quartzitic formation consists of conglomerates, microconglomeratic quartzites and coarse quartzites, usually coloured white to pink and also containing layers of fine quartzites. Intersected stratifications and ripple marks are often found in these quartzites. This formation is followed by alternating quartzites, quartzophyllades and schists. Then at the summit are found schists with quartzite intercalations.

The Middle Burundian, in contrast to the Lower Burundian, generally has sediments with a higher sandstone content. At the base of the Middle Burundian there is a large quartzitic formation (Muyinga - 1,000 m) consisting of fine to medium quartzite, coloured white to pink, rarely coarse and often well stratified. Intersected stratifications and ripple marks have been found here. This quartzite is overlain by schists, usually containing sandstone, with thin quartzite intercalations (Mikimba).

The Upper Burundian has more elastic sedimentation. It is represented by fine to medium quartzites, locally coarse and conglomeratic, alternating with schist-sandstones.

With the exception of a few thin metamorphized layers of magnesian limestone in the west of Burundi, the Burundian sediments are characterized by an alternation of large arenaceous and pelitic series, with the pelitic series containing sandstone intercalations.

The main structural directions of the Burundian run invariably N-E/S-W in the east of the country, but in the west they take different directions, often deviating on contact with granitic coves.

The Malagarasian belongs to the terminal Precambrian and outcrops in the south-east of the country in the Mosso region, where it rests in angular discontinuity on the Burundian. It is characterized on the one hand by very weak, or even non-existent, metamorphism, and on the other hand by unaccentuated tectonics in the form of only slight folding, with large-radius undulations.

The Malagarasian is subdivided into five groups which are, from oldest to most recent:

- The "Kavumwo group", consisting mainly of schists and phyllades with quartzite intercalations;
- The "Mutsindozi group", which includes conglomerates, quartzites, sandstones, calcareous schists and dolomitic limestones containing basalts in places;
- The "Nkoma group", with conglomerates, quartzites and phyllades;
- The "Kibago group" (the most recent), which consists of quartzites, sandstones and schists.

### III. GROUND WATER - BODIES CONCERNED

The governmental services and other bodies concerned with ground water in general are:

- The Hygiene Service, which comes under the Department of Epidemiology and the laboratories of the Ministry of Public Health;
- The Department of Rural Water Supply and Electrification (DHER), which is part of the Ministry of Rural Development;
- The Water and Electricity Production and Distribution Corporation (REGIDESO);
- The Municipal Technical Services Corporation (SETEMU); REGIDESO and SETEMU come under the Ministry of Public Works, Energy and Mines;
- The Geographical Institute of Burundi (LIGEBU), which reports directly to the President of the Republic. This body was established by decree No. 100/146 of 30 September 1980;
- The International Rural Development Association (IRDA), a private body working in close co-operation with the Ministry of Rural Development, specifically with the Department of Rural Water Supply and electrification (DHER);
- UNICEF, which collaborates with DHER.

These bodies have the following powers and responsibilities:

The Hygiene Service is responsible for monitoring the composition of drinking water, and domestic and industrial waste water.

The water responsibilities of DHER are: (i) evaluation and maximum use of all water resources for rural water supplies; (ii) training of personnel for the installation and permanent maintenance of water supply equipment; (iii) repair of delapidated equipment and ancient springs managed by the State or on the State's account; and (iv) study and construction of new water-supply installations.

REGIDESO is a commercial enterprise. Its function is to operate the water supply and distribution services and the electricity distribution services.

SETEMU is a public commercial enterprise. Its function is to carry out and operate, on behalf of the municipality of Bujumbura, all technical works, in particular drainage and road maintenance, removal of waste water and refuse, and construction and maintenance of municipal buildings.

The function of IGEBU is to promote geographic activities in Burundi. It has three departments:

- Department of Cartography and Topography;
- Department of Hydrometeorology and Hydrogeology;
- Department of Administration and Finance.

The Hydrogeology Service has the following functions:

- Field reconnaissance work with a view to identifying and making an inventory of aquifers;
- Detailed studies for the evaluation of the stocks of the aquifers identified;
- Study of the recharge properties of these aquifers and forecasting of their optimum yield with a view to rational exploitation;
- Study of the water quality of each aquifer and determination of its most appropriate use;
- Determination and appropriate installation of exploitation wells and boreholes;
- Determination of pollution-protection zones around installations.

#### Brief background

Between 1953 and 1961 some 270-300 exploration holes (with test pumping) were drilled in the Imbo and Mosso plains and at Rumongo. An index card was prepared for each installation, indicating:

- Location of the borehole, well or lined well;
- Implementation periods;
- Digging method;
- Successive diameters;
- Pumping method;
- Level of water below outlet, at rest;
- Pumping schedule;
- Water temperature;
- Probable depth of horizon;

- Approximate altitude of outlet.

Since 1962 IRDA, in collaboration with the Hydraulics Service, has dug 60 wells in the Mosso, at Imbo and at Rumongo, of which 12 are equipped with pumps in the Imbo plain and 15 in the Mosso (GIHOFI). These wells are 10 to 40 m deep.

The wells designed to supply small communities are drilled wells in which low-capacity manual pumps can be installed (600 l/h). On the basis of a standard consumption of 25 l/day per person in rural areas with a pumping rate of 3 h/day, a well ought to supply drinking water for a community of 80 persons. Heavier demands would have to be met by extending the pumping period.

Other boreholes with test pumping have recently been drilled for private companies (BRASSERIE, SOSUMO, S.A.B., and Hotel Tanganyika). Some of these boreholes are in operation.

Since the ground water is not sufficient to supply the GITEGA brewery, it has been decided to use surface water.

It should be noted that rural water supply works are designed mainly for the delivery of a guaranteed drinking water supply, largely from small springs, of which the country has several thousands. The following are the gaps yet to be filled in this area:

- Shortage of qualified multi-skilled personnel to manage the various development techniques;
- Lack of knowledge about the hydrological cycles of the basins and ground-water aquifers necessary for the evaluation of the long-term resources.

#### IV. EXPLOITATION OF GROUND WATER

The governmental services responsible for exploitation of ground-water resources are:

##### 1. Department of Rural Water Supply and Electrification (DHER)

- A hydrogeological office in the Programmes Service;
- A water supply office in the Equipment Service;
- A water supply office in the Management Service.

DHER has small tools and equipment for tapping springs, such as hoes, picks, shovels, and galvanized and PVC piping and water supply accessories. Senior staff are trained in the universities and higher institutes and other staff in the technical schools. Many members of the staff working on the installation and permanent maintenance of water supply equipment have been trained during their employment by the Department itself. The following are the private bodies working in collaboration with DHER in the field of rural drinking water supply:

- IRDA, a private body which is engaged in the digging of wells and installation of pumps in the Imbo and Mosso plains and in the rehabilitation of a number of springs;



- UNICEF, which is concerned with gravity-delivered water supplies and the development of springs, mainly to supply drinking water to health centres, clinics, schools and other infrastructures around these build-up areas.

2. REGIDESO is a public commercial enterprise which has a General Department and two subsidiary departments: the Technical Department and the Department of Administration and Finance.

The Technical Department has two offices: the Water Office and the Electricity Office. The Water Office is subdivided into four services:

- The Water Exploitation Service at Bujumbura;
- The Water Exploitation Service for the country's interior centres;
- The Works Service; and
- The Studies Service.

This Office has tipper trucks, vans, electrical pumps and mechanical pumps.

The staff of the Water Office is trained in various universities, institutes and technical schools in Burundi and abroad.

3. Drilling companies: IRDA is the only company so far working on ground-water exploitation.

It uses rotary percussion drills in the alluvial rocks. It has one driller-mechanic, one driller and two assistants. The latter have been trained on the job. The Department of Geology and Mines drilled more than 100 wells for test pumping in the Imbo plain, in the Mosso and at Nyanza-Lac before 1961. None of these wells was more than 25 m deep.

Ground water is exploited only in the Imbo plain and in the Mosso (GIHOFT). These are public wells equipped with pumps.

The population's water needs are at present met to the extent of 90 % in the towns and 70 % (public standpipes) in the secondary centres.

In the rural areas, the high-plateau zones are supplied with water from small springs, some of which are equipped with gravity-delivery systems: it is estimated that some 20 % of the population is served by satisfactory installations, and this proportion is to be increased to 50 to 60 % by 1990 with a threefold or fourfold increase in the daily volume of water supplied to the people.

In the lower areas of the plains, in contrast, only about 3 % of the population has gravity-delivered or well water in satisfactory quantities and of satisfactory quality; this proportion is to be increased tenfold by the 1990s, with larger amounts of water delivered per inhabitant and shorter walking distances to fetch water. This will require a substantial increase in ground-water exploration and exploitation. Lastly, it should be noted that the maintenance of the gravity-fed installations and the wells and boreholes equipped with pumps poses considerable problems. Some of these infrastructures have undergone serious deterioration and cannot therefore be used.

## V. CONCLUSION

Since Burundi's aquifers have only a modest yield, its surface water is abundant and its springs numerous, it is clear that ground-water research and exploitation - relatively difficult and costly operations - can be justified only in specific cases. In particular, there seems no question of ground water contributing usefully to the supply of the urban centres.

In rural areas infrastructures for human water supply have operating and maintenance problems. A special effort is being made to determine ways and means by which the people will itself be able to bear the cost of maintenance and replacement. Several solutions have been proposed: charges paid by the beneficiaries alone, payment of a lump-sum tax by all the residents of a commune, and payment of a social tax.

The exploitation of ground water by means of wells and boreholes is envisaged in the disadvantaged regions; springs will be developed and the water delivered by gravity and pumping (Kirundo, Cankuzo, Gihofi and Imbo).

This means that a considerable effort must be made to estimate the ground-water potential, about which little is yet known in these areas.

## VI. REFERENCES

- IRDA, Alimentation en eau potable pour l'installation future des populations de la vallée de Kayongozi, 1982-83.
- \_\_\_\_\_, Forage et aménagements de puits dans la plaine de l'Imbo, 1980.
- \_\_\_\_\_, Programme de forage et d'équipement de puits dans l'Imbo et le Mosso - Avancement des travaux, 1980.
- IGEBU, Organisation et structures, September 1980.
- Ministry of Rural Development, Forage de puits en milieu rural. Etude complémentaire des régions du projet.
- Nkarura, T., Cartographie géologique et localisation des ultrabasites, 1983-84.
- Nzotugicdempage, A., Contribution à l'étude du magnétisme basique dans le Kibarien de la partie occidentale du Burundi.
- Republic of Burundi, Plan décennal de la Décennie internationale de l'eau potable et de l'assainissement, January 1984.
- Geological Service, Fiches de forages réalisées dans les plaines de l'Imbo, du Mosso et de Nyanza-Lac avant 1961.