RWANDA WATER AND FORESTRY AUTHORITY

ANNUAL WATER STATUS REPORT 2016-2017

Rwanda endeavours to manage and develop its water resources in an integrated and sustainable manner, so as to secure and provide water of adequate quantity and quality for all social and economic needs.

These annual reports provide also relevant information to the reporting on the Sustainable Development Goals, specifically SDG 6:
"Ensure availability and sustainable management of water and sanitation for all" specifically on the following indicators:
Indicator 6.6.1 – "Change in the extent of water related ecosystems over time".
Indicator 6.3.2 – "Proportion of bodies of water with good ambient water quality".
This document is divided into:

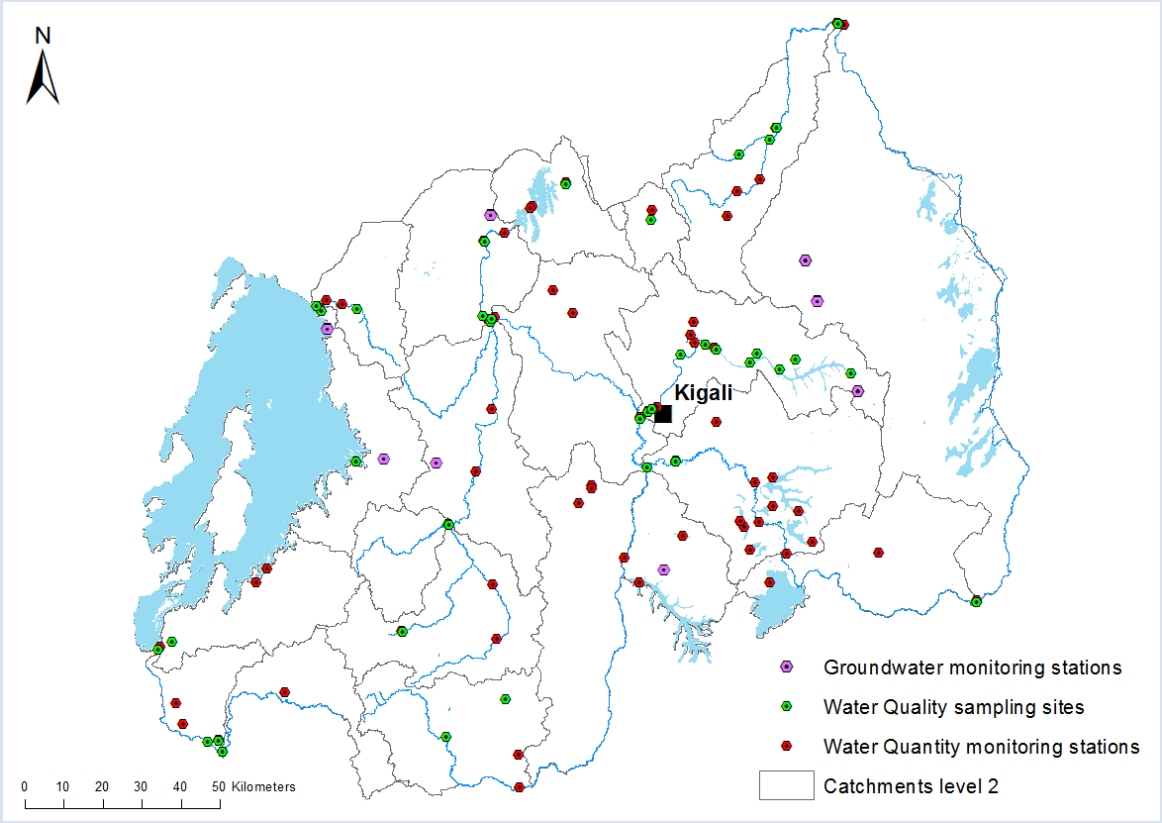
- Surface water quantity
- Ground water quantity

To enable evidence based decision-making, the Rwanda Water and Forestry Authority (RWFA) generates concise, easily understood annual overviews of key parameters and locations which are indicative of the overall state of Rwanda's water resources.

- Water quality
- Water use

The information is based on data collected through our monitoring programme which is designed to provide stakeholders and decision-makers with information to support the sustainable development and management of our water resources, improve water productivity and to plan for the future conditions resulting from climate change.

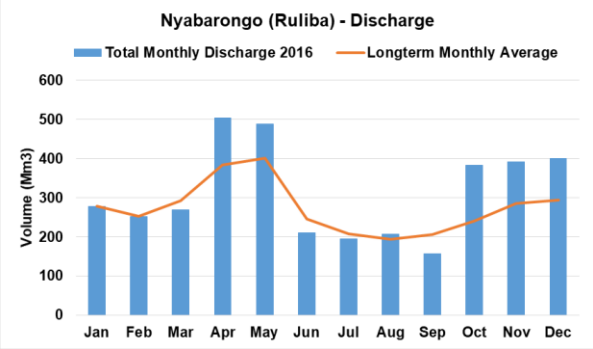
RWFA provides information and data on the water resources via the newly established Water Portal:
https://waterportal.rwfa.rw/



Surface water quantity

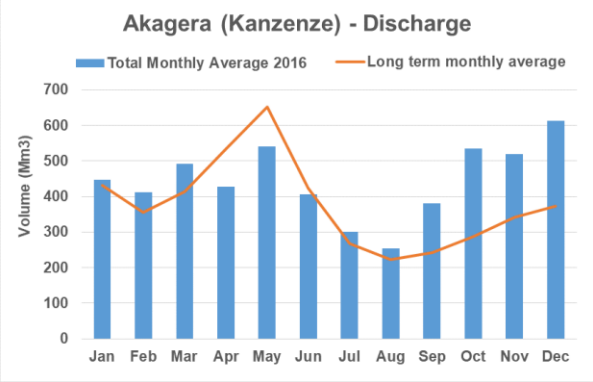
Information on the availability of water resources is critical for addressing short term and long term needs. For this, RWFA monitors lake levels and river flow (or discharge) at strategic locations (refer to map above). This report aims at presenting water quantity information for 2016 (the hydrological year) for several key locations. This information is compared to long term trends for easier reference. In each of the time series graghs, bold red line represents the observed flow of long term trends. The blue bars indicates the total flow in each month in 2016.

The flow of the Nyabarongo River at Ruliba (see below) reached the highest level during the early wet season (April-May) showing the influence of heavy rainfall., However, the flow was gradually decreased from June to september.



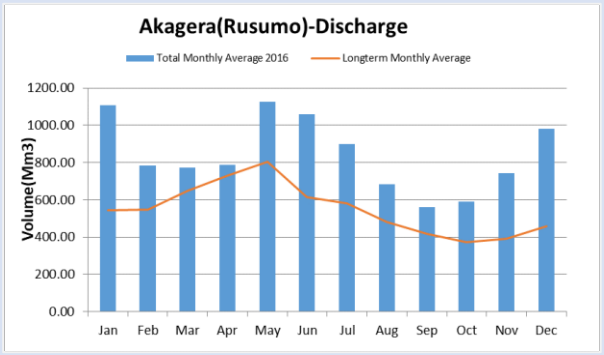
Data Source: RWFA/IWRMD

The flow of the Akagera River at Kanzenze (see below) during the 2016 wet season was significantly below the long term average whilst the remaining period flows were above the long term average. As the Kanzenze station receive flow for Akanyaru river as another input, there is a chance of low flows due to lowest rainfall occurred in upstream part includes also a part in Burundi.



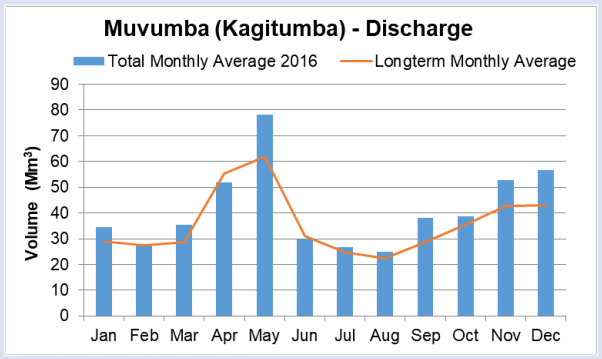
Data Source: RWFA/IWRMD

The flow of the Akagera River (bordering Burundi and Tanzania) at Rusumo (see below) in 2016 was higher than its long term average due to the influent inflows from the upstream reaches.



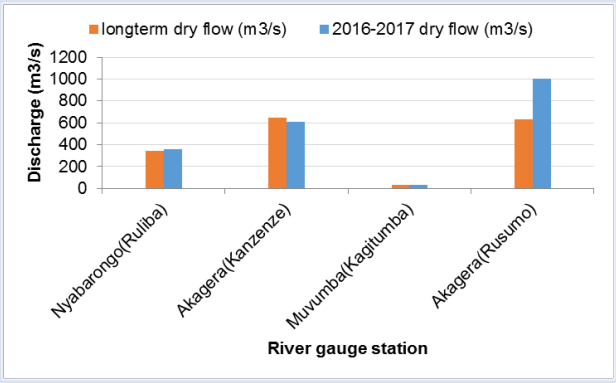
Data Source: RWFA/IWRMD

The flow of the Muvumba River (bordering Uganda) at Kagitumba (see below) in 2016 was higher in May than its long term monthly average and the rest of the months are below .



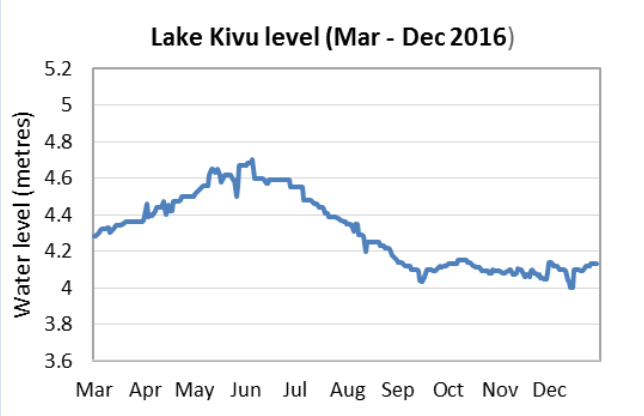
Data Source: RWFA/IWRMD

The flow discharge from Nyabarongo river, Akagera river and Muvumba river, with four main gauge stations: Ruliba, Kanzenze, Kagitumba and Rusumo gauge stations respectively (Figure below). The results show no siginaficant change in monthly dry discharge 2016-2017 and longterm dry months at the Nyabarongo lower, Akagera upper and Muvumba river. Changes of dry monthly discharge at the Akagera lower(Rusumo station) are eveident, and other flow from Burundi apear to be responsible for the seasonal variation of flow discharge.



Data Source: RWFA/IWRMD

The water level of Lake Kivu (see below) is also being recorded. Data for 2016 shows that lake levels are at the highest during May and June before dropping by 0.7 metre towards september. This seasonal variation is typical for Kivu and reflects the rainfall patterns, it is also reservoir water releases from rusizi hydropwer controls over the flow of the Rusizi River.

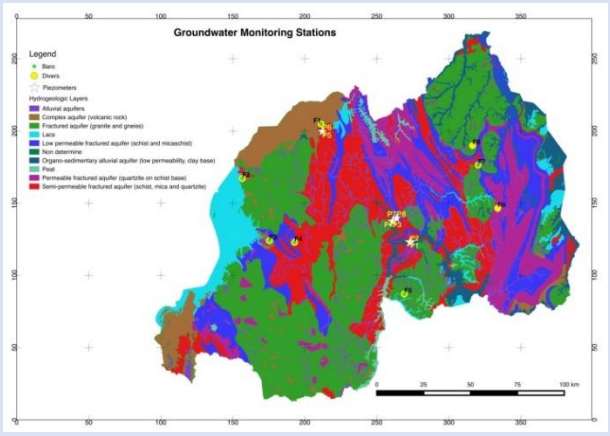


Data Source: RWFA/IWRMD

The main finding of this report show the effect of rainfall and climate variation on river flow rates. The flow analysis was produced by using monthly mean river flow derived from the average of 2016 river flow estimates within each gauging station and compared with historical flow estimates. The location of the reference gauging stations is as follow:Ruliba station at Lower Nyabarongo river, Kanzenze station at Upper Akagera river, Rusumo station at lower Akagera river, Kagitumba station at Muvumba river and Lake Kivu as shown in the above figures.

Groundwater quantity

Knowledge regarding Rwanda's groundwater resources is still very limited and RWFA has begun construction of groundwater monitoring infrastructures, inventorising groundwater wells and geophysical investigations of groundwater resources. These measures will ensure a better understanding of the trends in groundwater use and availability. for the future Annual Water Status Reports. Currently, the overall trend in groundwater availability is not yet well known. RWFA is taking measures to fill this knowledge gap.



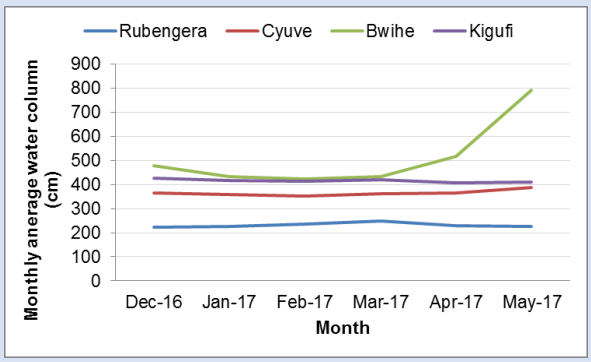
Most aquifers in Rwanda are found in fractured rocks with the exception of lava regions and in south west where complex aquifers can be found (see mapabove). The potential quantity of ground water depends on the local porosity of the rock. Alluvial aquifers are usually shallow, narrow and follow river valleys and have high recharge rates due to their close connection with river and wetlands. They are usually heavily exploited due to their ease of access. Fractured aquifers tend to be localised and permeability (and thus yield) depends heavily on the density and interconnection of fractures.

Figure above shows different hydrogeologic regions for Rwanda and established ground water monitoring network. The geological formation in the eastern province is characterised by granitic rocks which are widely distributed. Along the western province border, metamorphic rocks are distributed in a narrow belt shape. In the central and south-eastern parts of the country, metamorphic rocks of quartzite and schist and sedimentary rocks of mudstone and sandstone are distributed in the north-south direction.
Groundwater level data is now recorded using monitoring divers on 8 monitoring boreholes countrywide and 8 piezometers on Nyabugogo, Akagera, Mukungwa and Nyabarongo rivers as illustrated in the figure above.

The graph below shows the water column variation in groundwater monitoring boreholes located in Musanze, Karongi and Rubavu.
The borehole of Bwihe site located in Karongi (Figure below) indicates high variation due to the water abstraction from the nearby spring. For other three boreholes, the variation is not significant and

Knowledge regarding Rwanda′ s groundwater resources is still very limited. RWFA started construction of groundwater monitoring infrastructures, inventorising groundwater wells and geophysical investigations of groundwater resources to ensure better understanding of the trends in groundwater use and availability.

may be due to their location covered by stagnant water for long period and water table is often close to surface.



Data Source: RWFA/IWRMD

Water-level measurements from observation wells are the principal source of information about the hydrologic stresses acting on aquifers and how these stresses affect groundwater recharge, storage, and discharge

Water quality

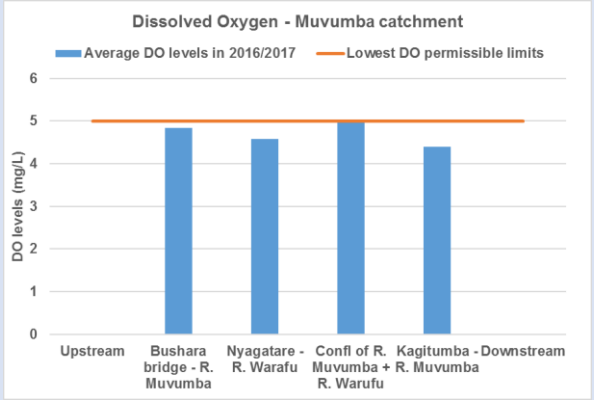
Poor agricultural practices and poor mining on steep slopes as well as discharges of wastewater from domestic and industrial facilities are the principal cause of poor water quality in Rwandan water bodies and this may affect aquatic ecosystems, reservoir and river siltation, excessive nutrient loads and drinking water quality.

This status report focuses on three key parameters of which two of them Electrical Conductivity and Dissolved Oxygen (EC and DO) are included into SDG 6.3.2 core parameters and are used as common indicators of water quality, whilst a third one (turbidity) was added due to its relevance as an indicator of sedimentation in the country's water resources

Data used in this report are mean levels from sampling exercises conducted in two phases: the first phase from mid-September 2016 to November 2016 while the second phase targeted the wet season from April to May 2017.

In Nyabarongo catchment, dissolved oxygen levels varied from 5.14 mg/L and 7.47 mg/L and were within the permissible limit of 5mg/L. Similarly, DO levels in Rusizi catchment ranged from 6.68mg/L (at Rubyiro bridge-River Rubryiro) to 7.65mg/L at Ruhwa bridge-River Ruhwa and all sites recorded DO levels within permissible limits.

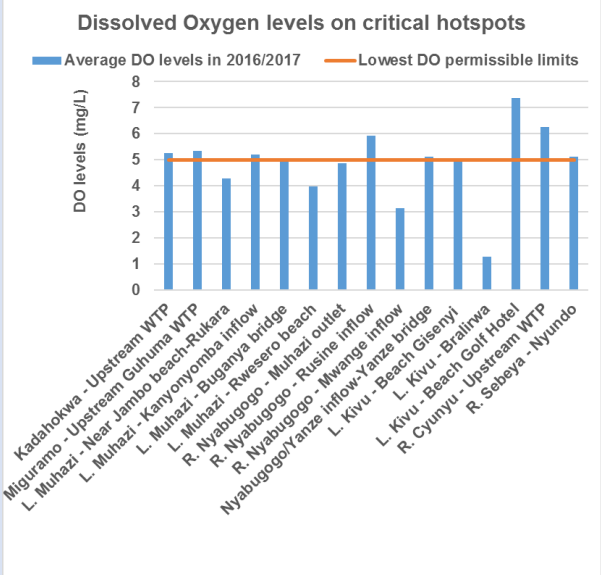
However, DO levels crossed the lowest allowable threshold of 5mg/L for different sites considered in Muvumba catchments and on key hotspots as indicated by the figures below:



Data Source: RWFA/IWRMD

Except for sampling sites at the confluence of the Rivers Warufu and Muvumba, DO levels in Muvumba catchment were found below permissible limits at almost all points sampled which indicates deterioration water quality by oxygen consuming pollutants.

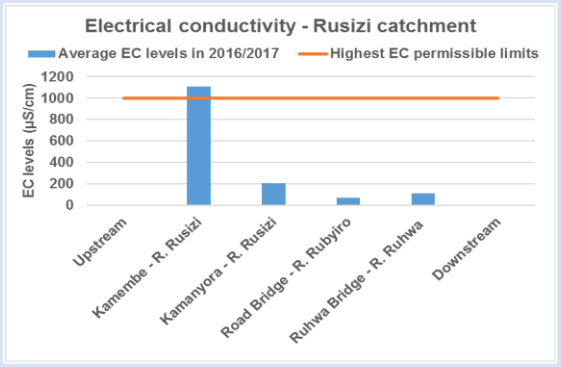
Similarly, several locations are deemed 'Hotspots', either due to their importance as bathing sites, water abstraction points (upstream of Water Treatment Plants – WTPs) or in relation to noted polluters recorded DO levels below permissible limits. This is the cases of Lake Kivu near the Bralirwa brewery site, Lake Muhazi and River Nyabugogo



Data Source: FWFA/IWRMD

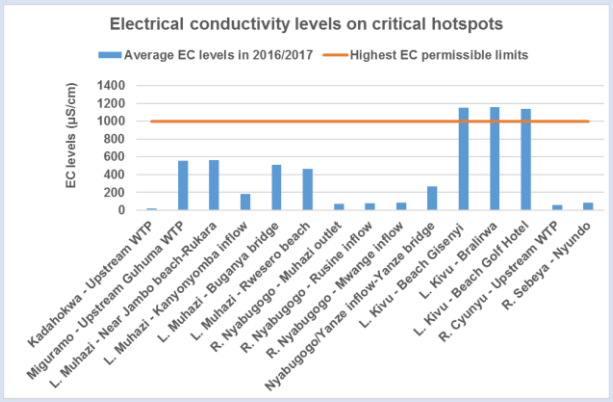
For electric conductivity, its mean levels ranged between 35.67 and 88.57µS/cm in Nyabugogo and 212.50 and 244.75 µS/cm in Muvumba and were within the highest permissible limit of 1000µS/cm at all points considered.

On the other hand, in Rusizi catchment, EC levels crossed highest permissible limits for the sites located at the exit of Lake Kivu. Similarly, hotspots sites located along Lake Kivu recorded EC levels above the highest permissible limit as shown on figures below:
EC levels for the Nyabarongo catchment are well below the permissible limits.



Data Source: RWFA/IWRMD

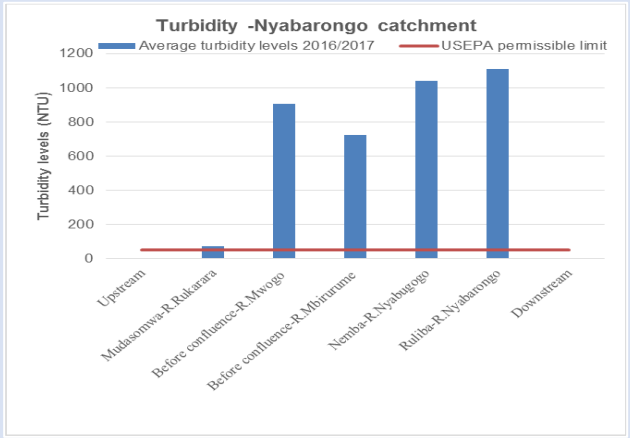
Except for the Rusizi River at exit of Lake Kivu, EC levels at other sites are within permissible limits in Rusizi catchment.



Data Source: RWFA/IWRMD

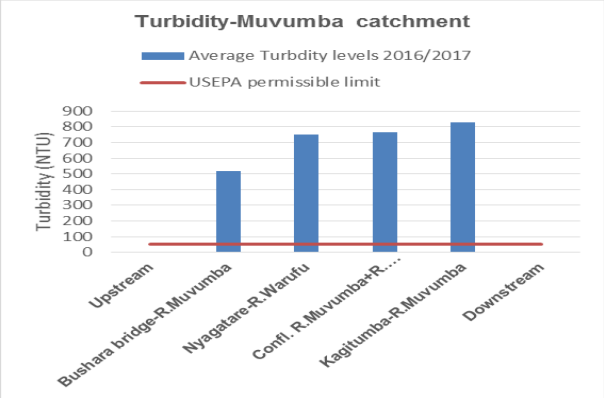
EC levels on almost critical hotspots were within permissible limits except for L.Kivu-(beach Gisenyi, Bralirwa and beach Golf Hotel sites)

Turbidity levels were found to be high in most of the catchment considered, compared to a highest turbidity limit in ambient surface water of 50 NTU (US EPA). Turbidity in surface water can have adverse effects including inhibition of photosynthesis, reducing aquatic plant and algae growth as well as reducing visibility for fish and ather aquatic species.



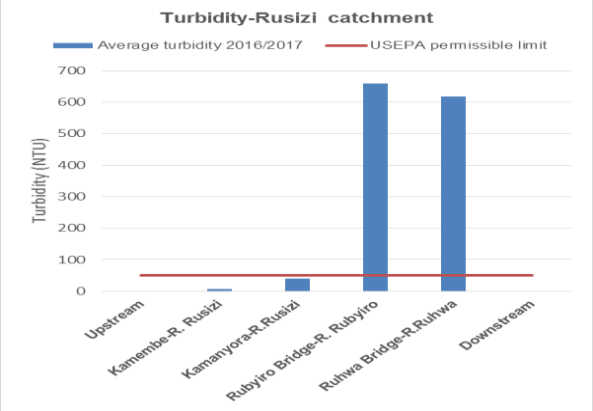
Data Source: RWFA/IWRMD

Except for River Rukarara which slightly crossed the permissible turbidity level, turbidity levels at the other sites significantly crossed that permissible limit.



Data Source: RWFA/IWRMD

Turbidity levels in Muvumba catchment were found high compared to US EPA threshold of 50 NTU in stream waters



Data Source: RWFA/IWRMD

Rubyiro and Ruhwa rivers recorded highest turbidity levels, exception to Rusizi River at Kamembe and Kamanyora which recorded turbidity levels below US EPA threshold level.

To sum up, water quality monitoring 2016/2017 revealed:

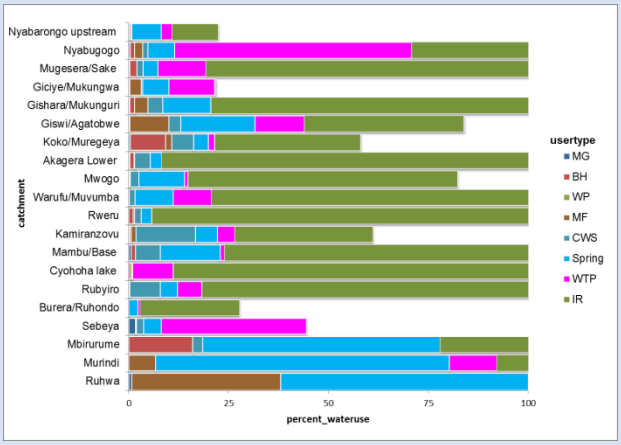
- High turbidity in all catchment as a result of soil erosion;
- Lake Kivu and Lake Muhazi recorded high values of pH and salinity (Electrical Conductivity and Total Dissolved Salts);
- Sites such as Lake Muhazi, Lake Kivu (Bralirwa), River Akanyaru downstream, River Rusizi at Kamanyora as well as River Rusineshow have low DO levels indicating pollution by organic matter.

In 2017/2018, the water quality monitoring programme will focus on collecting water quality data on permanent sites, emphasizing on water quality parameters of pollution concern such as E.coli, fecal coliforms, nutrients, tubidity, ….and including the five SDGs indicator 6.3.2 core parameters (Dissolved Oxygen, pH, Electrical Conductivity, Dissolved Inorganic Nitrogen and Dissolved Inorganic Phosphorus).

Water use

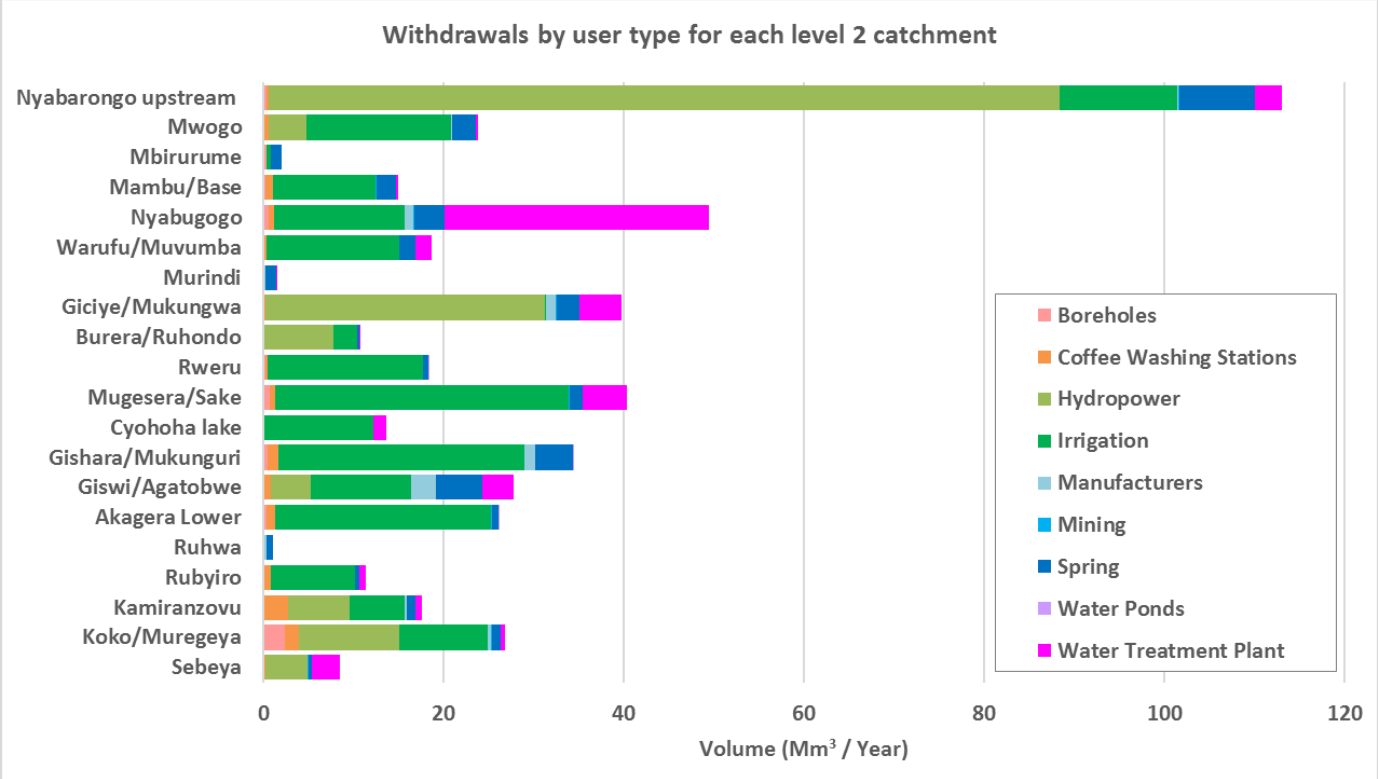
The highest water withdrawal availability ratios were observed in Akagera upper (NAKU), Nyabarongo Upper (NNYU) and Muvumba catchments (NMUV) with an annual ratio of 11.62%, 10.78 and 10.48%, respectively. Highest abstractions were observed in irrigation and by Hydropower plants with 222 and 157million m^3/year respectively.

For hydropower water use, only 5% of the total water abstracted is here considered, as derived from international comparative studies on hydropower systems, which consider the factors of water loss in such systems comprising of cooling systems, the amount of water that is evaporated, both at the site and indirectly at the power plant (Torcellini et al., 2003).



Data Source: RWFA/IWRMD

The Nyabugogo sub-catchment is dominated by water treatment (domestic supply in and around Kigali) and irrigation, whilst hydropower dominates the upper Nyabarongo and Mukungwa catchments. Additionally, irrigation is by far the largest single consumptive user (222 MCM or 45%) with a wide spread across the catchments.



Conclusion

The collection, analysis and presentation of data on hydrology, water quality, groundwater and water users presented in this annual water status is expected to contribute to a proper planning for water resources related plans as well as a better design of water related infrastructures.

Dissemination of information on water resources will continue to be an important part of the Rwanda Water and Forestry Authority's ongoing activities.