

Groundwater resources in Rwanda

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1. Introduction

- Renewable groundwater of Rwanda was estimated to be 401 million cubic meters a year:
 - **Renewable aquifers : 315 million m³**
 - **Deep aquifers: 86 million m³**
- In Rwanda groundwater is not **extensively exploited**. However, it is the major source of clean water for rural areas (in form of springs)
- Main source of drinking water in Umutara district (semi-arid zone with insufficient surface water)

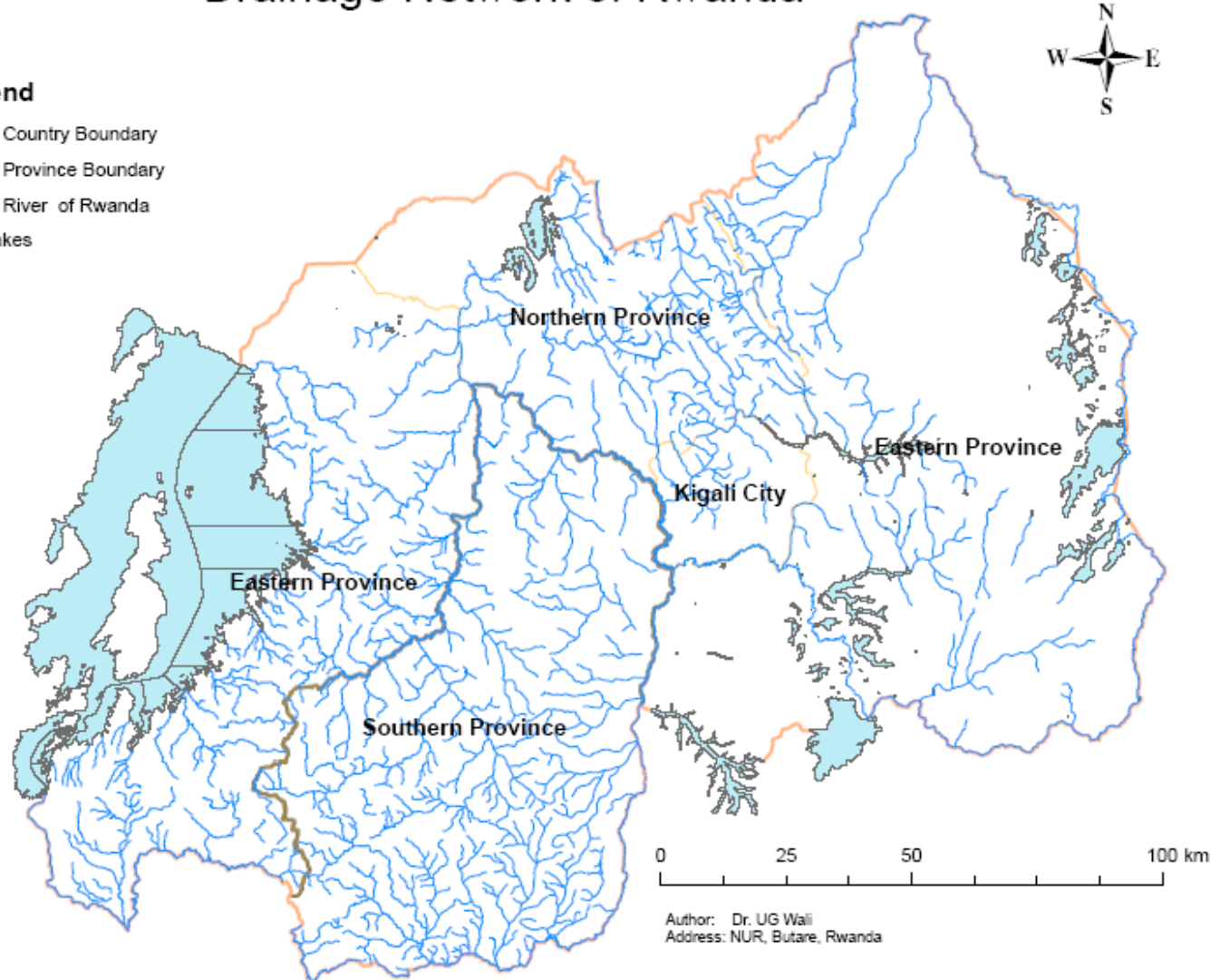
2. Water resources availability in quantity and quality

- Water resources covers about 10% the Rwanda territory
- Lakes: 128.190 ha
- Rivers: 7.250 ha
- Wetlands: 77.000 ha
- Number of Springs : 22.300

Drainage Network of Rwanda

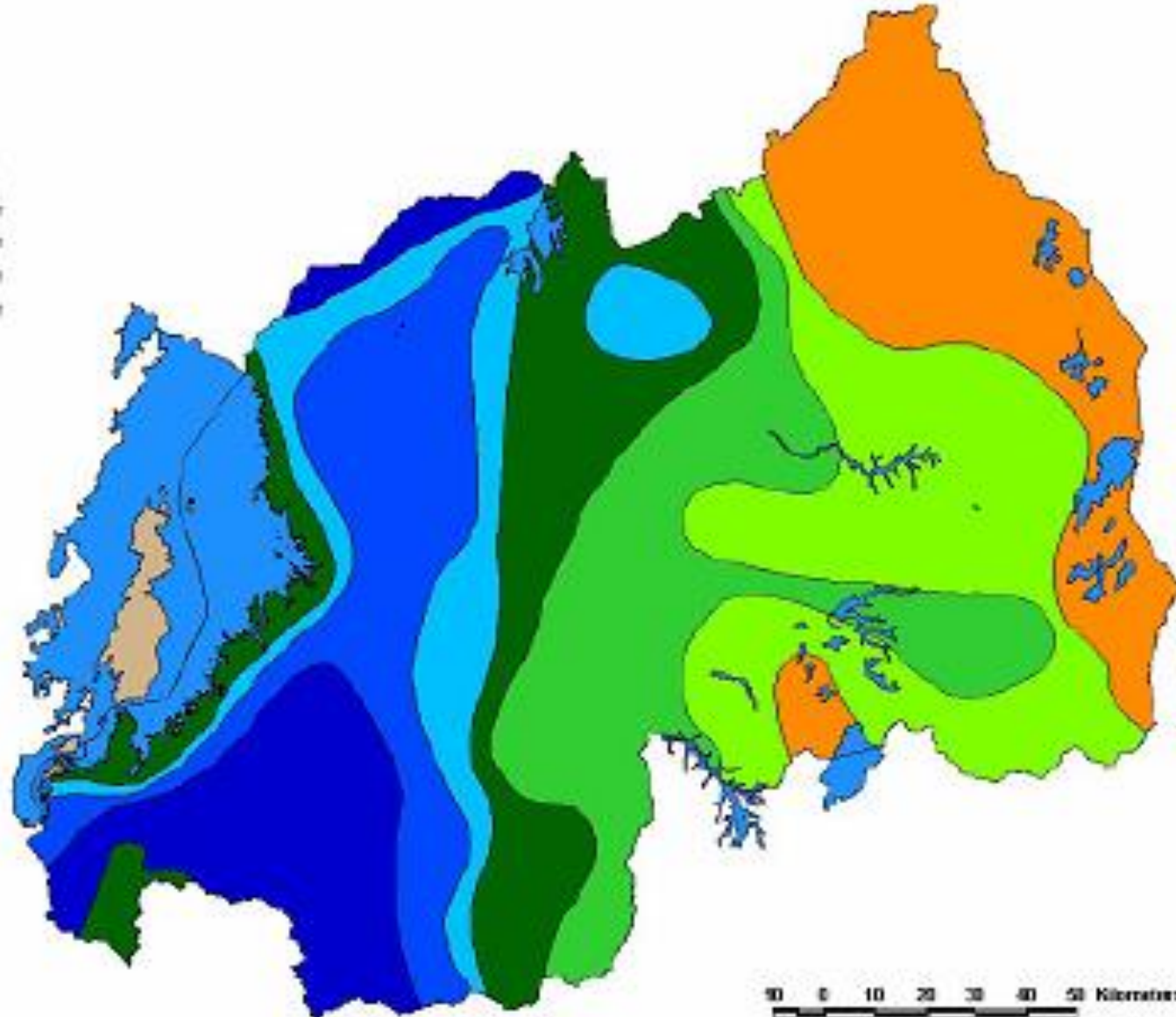
Legend

- Country Boundary
- Province Boundary
- River of Rwanda
- lakes



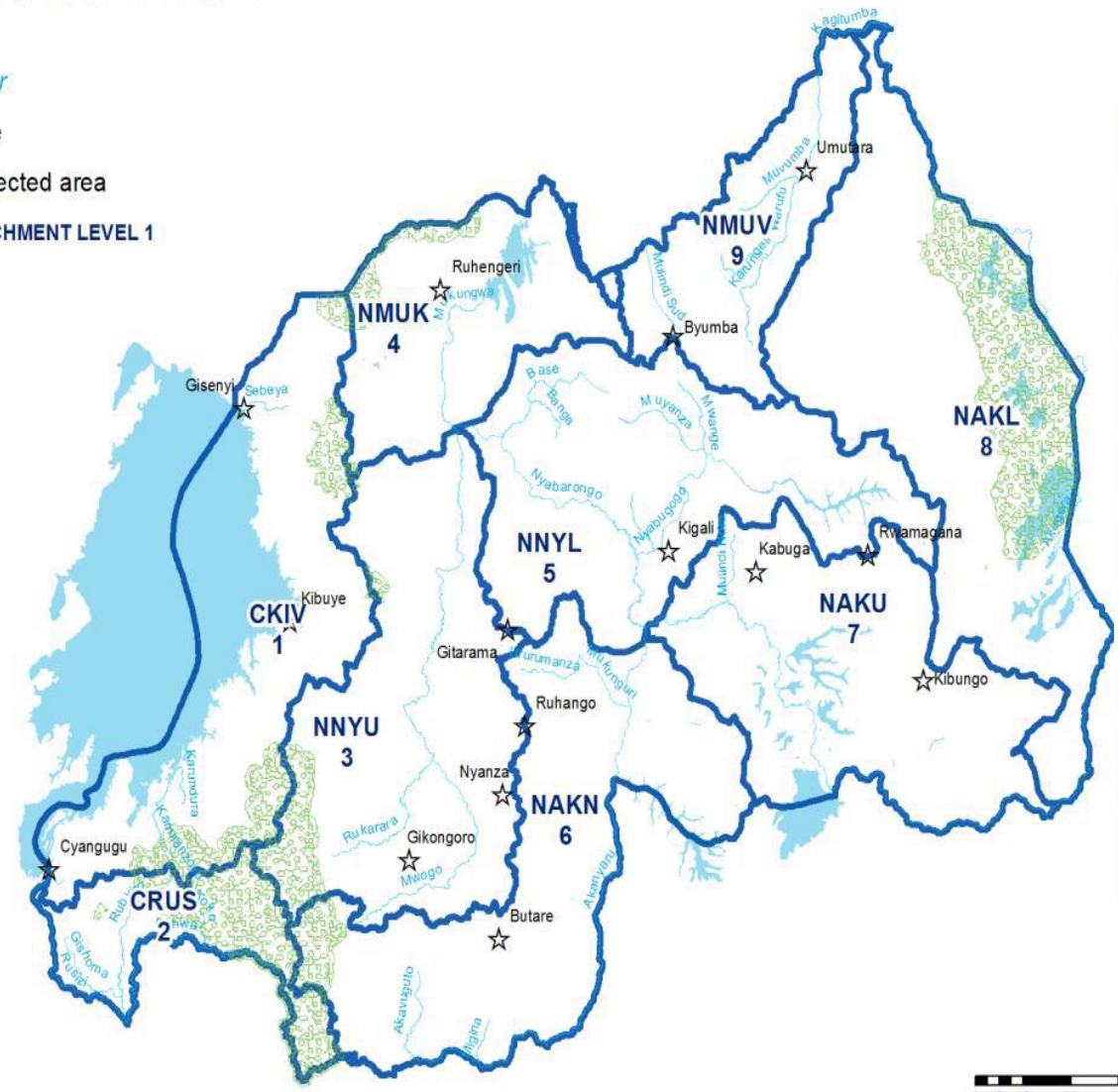
► **An average annual rainfall of 1200 mm / year**

Precipitation

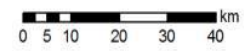


Catchments level 1

- ☆ City
- River
- Lake
- Protected area
- CATCHMENT LEVEL 1



No	Code	Basin	Catchment Name	Surface [km ²]
1	CKIV	Congo	Lake Kivu	2.425
2	CRUS	Congo	Rusizi	1.005
3	NNYU	Nile	Nyabarongo upper	3.348
4	NMUK	Nile	Mukungwa	1.887
5	NNYL	Nile	Nyabarongo lower	3.305
6	NAKN	Nile	Akanyaru	3.402
7	NAKU	Nile	Akagera upper	3.053
8	NAKL	Nile	Akagera lower	4.288
9	NMUV	Nile	Muvumba	1.565





Catchment Number	1	2	3	4	5	6	7	8	9
Code NWRMP	CKIV	CRUS	NNYU	NMUK	NNYL	NAKN	NAKU	NAKL	NMUV
Name:	Lake Kivu	Rusizi	Upper Nyaborongo	Mukungwa	Lower Nyaborongo	Akanyaru	Upper Akagera	Lower Akagera	Muvumba
Surface area [km ²] in Rwanda	2 425 km ²	1 005 km ²	3 348 km ²	1 887 km ²	3 305 km ²	3 402 km ²	3 053 km ²	4 288 km ²	1 565 km ²
Total surface area [km ²]	7 323 km ² incl. lake 2 695 km ²	2 011 km ² , total basin: 9 334 km ²	3 348 km ²	1 949 km ²	3 305 km ²	5 328 km ²	3 053 level 1 basin, total basin 30 632 km ²	6 648 level 1 basin, total basin 37 288 km ²	3 711 km ²
Upstream national dependencies	none	Lake Kivu	none	none	Upper Nyaborongo & Mukungwa	none	Upper & Lower Nyaborongo & Akanyaru	Upper Akagera	none
Upstream international dependencies	none	Lake Kivu DRC	none	Insignificant (Uganda)	none	none	none	Ruvubu river Burundi	none

Catchment Number	1	2	3	4	5	6	7	8	9
Code NWRMP	CKIV	CRUS	NNYU	NMUK	NNYL	NAKN	NAKU	NAKL	NMUV
Shared catchment	2 203 km ² DRC	368 km ² DRC 638 km ² Burundi	none	62 km ² Uganda	none	1 926 km ² Burundi	13 714 km ² Burundi	2 354 km ² Tanzania	2 146 km ² Uganda
Av. annual rainfall [mm/yr]	1 240	1 295	1 365	1 315	1 191	1 225	925	835	995
Av. annual evaporation (water balance) [mm/yr]	870	865	980	851	919	990	760	624	872
Av. annual surface water runoff [mm/yr]	370	430	385	464	272	235	165	211	123
Base flow* [m ³ /s]	1,8°	3,8°	34,2	21,5	66,8+	16,4°	198,0+	200,0+	3,5
Av. annual ground water recharge [mm/yr]	250	350	292	322	165	227	115	125	71
Ground water volume storage [MCM]	2 425	5 025	25 110	4 870	8 673	5 103	4 580	4 820	1 570
Ground water mean resident time [year]	4	14	26	8	16	7	13	9	14
Ratio surface water / rainfall - annual [-]	0,30	0,33	0,28	0,35	0,23	0,19	0,18	0,25	0,12
Ratio ground water / rainfall - annual [-]	0,20	0,27	0,21	0,24	0,14	0,18	0,12	0,15	0,07

*: Base flow: when number marked with an ° it is for a partial catchment (Sebeya for CKIV, Rubyiyo for CRUS and upstream for NAKN); when marked with a + the base flow comprises flow from upstream catchments.

Surface and Ground Water Resources of Rwanda

National Water Resources Master Plan

Legend

- Built-Up Area
- Lake
- District
- Basin level 1

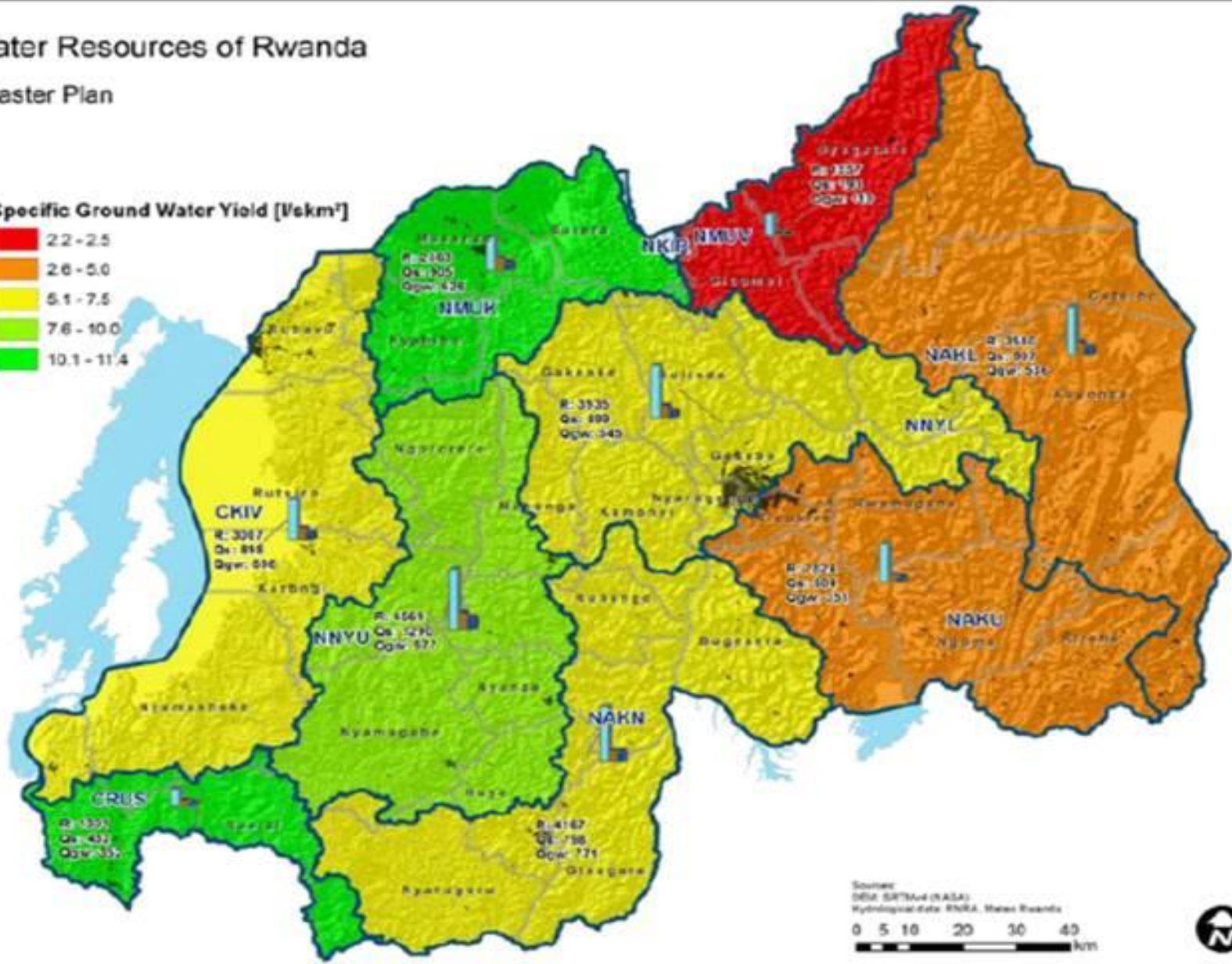
Water balance *

- 2 300
- Rainfall (R) [Mm³]
- Surface Flow (Qs) [Mm³]
- Ground Water Yield (Qgw) [Mm³]

Specific Ground Water Yield [l/skm²]

- 2.2 - 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 11.4

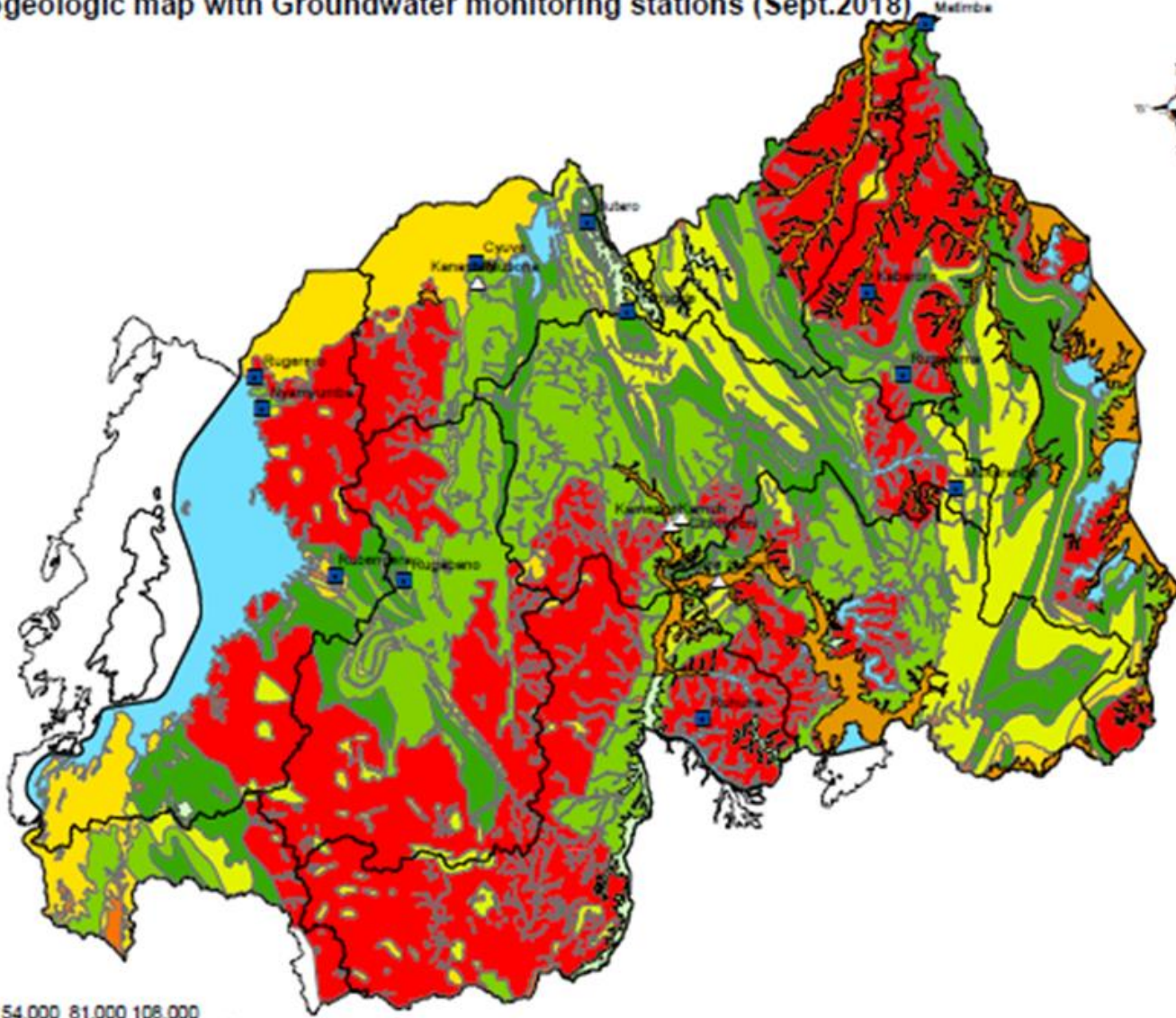
* Per basin volumes in million cubic meter [Mm³]
 R: Accumulated annual rainfall
 Qs: Accumulated annual surface flow in rivers containing ground water flow (Qgw)
 Qgw: Accumulated annual groundwater flow generated by recharge



Source: IGRAC, BGR, SRTM4 (NASA)
 Hydrological data: IGRAC, Mean Rwanda
 0 5 10 20 30 40 km



Hydrogeologic map with Groundwater monitoring stations (Sept.2018)



Legend

- Automatic_GWM_Stations
- Piezometers
- Boreholes_completed_up_to_Nov2018_part2
- BH in metric coord#&' Events
- Catchments_level1

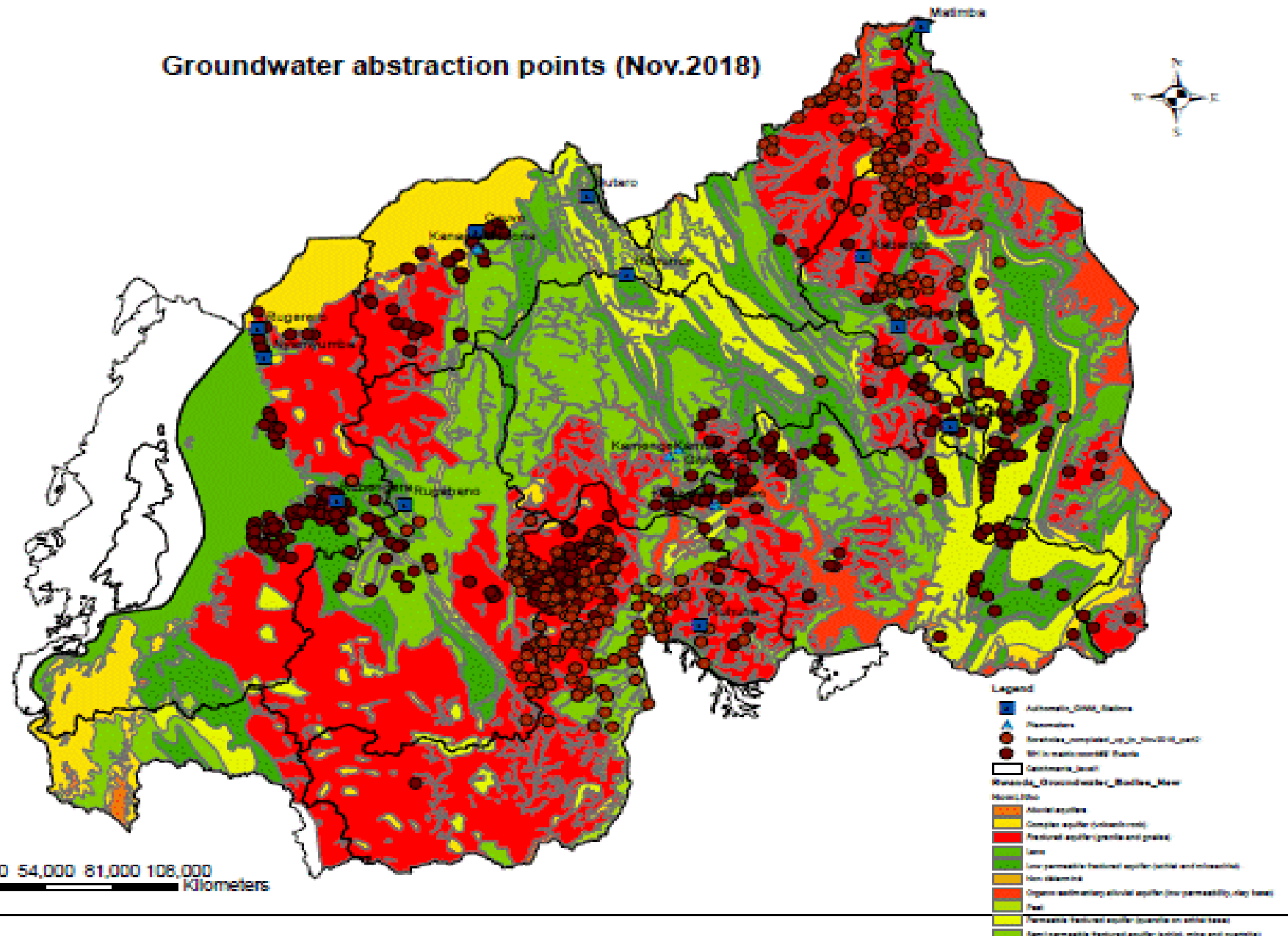
Rwanda_Groundwater_Bodies_New

NomLitho

- Alluvial aquifers
- Complex aquifer (volcanic rock)
- Fractured aquifer (granite and gneiss)
- Lacs
- Low permeable fractured aquifer (schist and micaschist)
- Non déterminé
- Organo-sedimentary alluvial aquifer (low permeability, clay base)
- Peat
- Permeable fractured aquifer (quartzite on schist base)
- Semi-permeable fractured aquifer (schist, mica and quartzite)

0 13,500,000 54,000 81,000 108,000
Kilometers

Groundwater abstraction points (Nov.2018)



- Legend**
- Automatic OMD Stations
 - ▲ Rivers
 - Abstraction points (Nov.2018)
 - Abstraction points (Nov.2018)
 - Districts (Nov.2018)
 - Alluvial aquifer
 - Complex aquifer (sandstone)
 - Fractured aquifer (granite and gneiss)
 - Lami
 - Low permeability fractured aquifer (partial and interstitial)
 - Non alluvial
 - Organic matter rich alluvial aquifer (low permeability, clay loam)
 - Sand
 - High permeability fractured aquifer (partial and interstitial)
 - Low permeability fractured aquifer (partial, interstitial)

0 13,200,000 54,000 81,000 108,000
 Kilometers

3. Groundwater quality



- In 2018 a Rapid Assessment of Drinking Water Quality (RADWQ) has been conducted by Rwanda Utility and Regulatory Authority (RURA)
- samples size of 602 water samples were collected countrywide from boreholes, spring & tap water in rural area for quality analysis .



Sample size per water supply type and province (RURA, 2018).

	Total	Kigali City	Northern	Eastern	Southern	Western
Sample size for water supply samples						
Public taps	249	0	53	79	46	71
Springs	253	0	52	35	94	72
Boreholes	100	0	2	79	7	12
Total	602	0	107	193	147	155
Sample size for household water samples						
Public taps	123	0	28	38	23	34
Springs	119	0	25	15	47	32
Boreholes	54	0	1	42	4	7
Total	296	0	54	95	74	73

Drinking water quality parameters included in the RADWQ for rural areas of Rwanda and permissible levels as per Rwanda standard for treated potable water and for natural (i.e. untreated) potable water (FDEAS 12:2018)

Type	Parameter	Rwandan Standard for treated potable water	Rwandan Standard for untreated potable water
Microbial	E. coli	not detectable in 100 mL	not detectable in 100 mL
	Turbidity	< 5 NTU	< 25 NTU
Physiochemical	pH	6.5 – 8.5	5.5 – 9.5
	Electroconductivity	< 1,500 μ S/cm	< 2,500 μ S/cm
	Odour	not objectionable	not objectionable
	Arsenic	< 0.01 mg/L	< 0.01 mg/L
Chemical	Fluoride	< 1.5 mg/L	< 1.5 mg/L
	Nitrate	< 45 mg/L	< 45 mg/L
	Iron	< 0.3 mg/L	< 0.3 mg/L
	Manganese	< 0.1 mg/L	< 0.1 mg/L
	Lead	< 0.01 mg/L	< 0.01 mg/L
	Cadmium	< 0.003 mg/L	< 0.003 mg/L
	Mercury	< 0.001 mg/L	< 0.001 mg/L

Issues of High Concern	Issues of Moderate Concern	Issues of Low Concern
<p><i>E. Coli</i> (41%) : This indicates that the water is contaminated with faecal pathogens. This leads to diarrheal diseases which are a leading cause for mortality among children below 5 years.</p>	<p>Fluoride (90%): the level detected, maximum 5.5 mg/L, is only moderately high. The population is at risk to develop dental fluorosis, which is not a major health concern.</p>	<p>Electroconductivity (100%): indicates the salinity of water. Salinity is not a concern in rural areas of Rwanda.</p>
<p>Turbidity (89%) : One-third have high or very high turbidity levels (above 5 NTU) which may impact user satisfaction and microbial quality.</p>	<p>Manganese (43%): standards is 0.1 mg/L. Adverse effects on learning in children caused by manganese are only expected if the concentration exceeds 0.4 mg/L.</p>	<p>Odour (89%): it is classified as minor concern because there is no direct health impact caused by odour.</p>
<p>pH (61%): More than one-third of the water supplies have a pH below 5.5. When pH is below 6.5, there is an increased potential for corrosion of metal pipes and fittings.</p>	<p>Mercury (74%): Risk of adverse health effects such as serious damage to the kidneys, brain, and nervous system.</p>	<p>Nitrate (97%): can be a serious health risk, especially to infants below one year. At that age infant are exclusively breastfeed, therefore the risk is minor</p>
<p>Arsenic (94%): The high levels of arsenic, above 10 µg/L, mean that this population is at risk of developing skin diseases and cancers.</p>	<p>Iron (85%): can have increased turbidity, discoloration and can affect taste. While there is no health risk for water containing iron, users often find the water unacceptable.</p>	<p>Lead (100%): is a developmental neurotoxicant associated with reduced cognitive development and intellectual performance in children, Cadmium (100%): causes kidney damage. Both HM are a minor issue in rural area of Rwanda</p>

Comparison with other countries:

While urgent action is needed to improve microbial water quality in rural areas of Rwanda, the RADWQ results show that, in comparison to the water quality situation in rural areas of other sub-Saharan countries, Rwanda is performing relatively well. *The Rwanda RADWQ excludes surface water which is used by approximately 6% of the rural population and is assumed to be high or very high risk. The Rwanda RADWQ also excludes the rural population of Kigali City, users of protected and unprotected wells, and rain water; for which it can be assumed that the risk levels are similar to the ones of the water supply types included in the RADWQ.

Faecal contamination of rural drinking water varies widely across countries in sub-Saharan Africa.

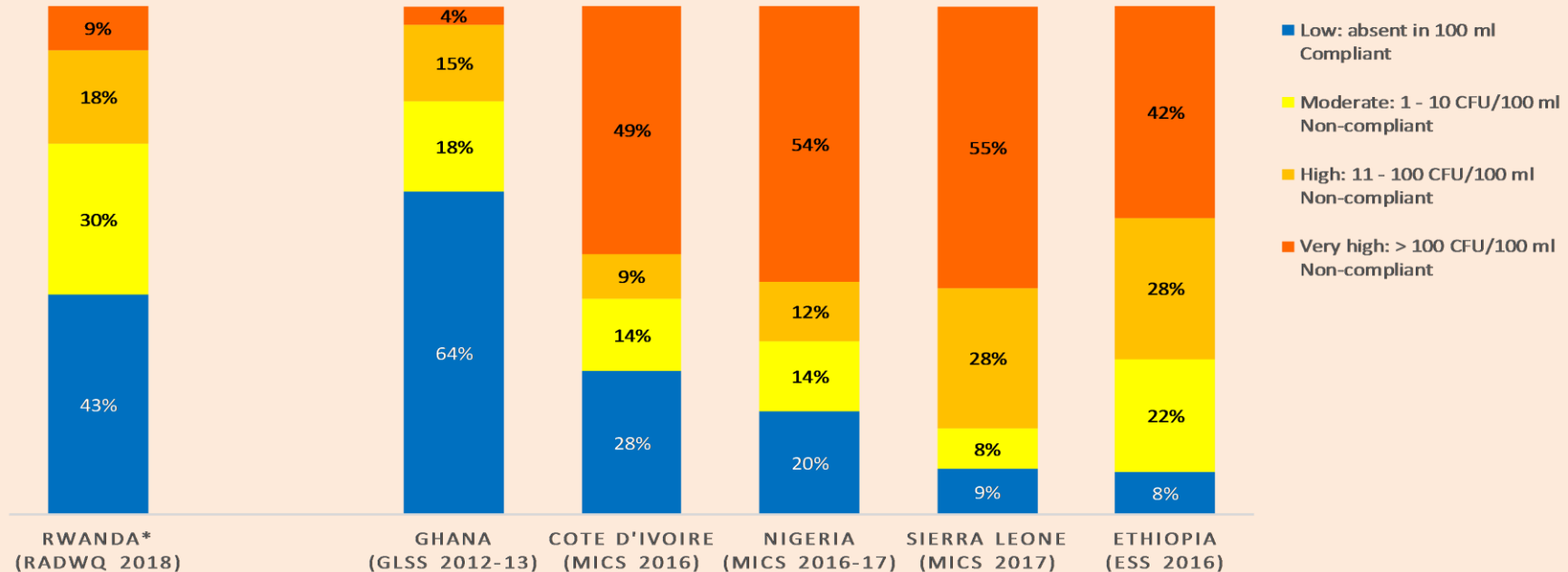


Figure 1: Comparison of E. coli contamination with other Sub-Saharan countries

Conclusion and Recommendations

- Groundwater resources management requires information on the changes in the status of the water resources which is based on rainfall data, rock type, groundwater and surface water abstraction data, groundwater levels and stream discharges and water quality information.
- Proper groundwater management needs to be based on reliable groundwater data. One of the biggest challenges is the collection of groundwater information. There is no habit in the recording of drilling activities, lack of well logs,... in order to address these issues the authority in charge of groundwater has the obligation to request all stakeholders to fill forms providing information on all drilled boreholes.



Thank you for your kind attention