Basin Risk Indicators - Descriptions, Sources and Links

Risk type	Risk category	#	Risk indicator	Description	Source	Link
Physical Risk	**1. Water Scarcity**	**1.0**	Aridity Index	An aridity index was generated based on the ratio of Potential Evapotranspiration (PET) to Mean Annual Precipitation (MAP). The layer was simplified from raster scale data using a mean value per quaternary catchment.	Schulze, R.E. (Ed). (2007). South African Atlas of Climatology and Agrohydrology. Water Research Commission, Pretoria, RSA, WRC Report 1489/1/06, Section 1.3. Schulze, RE., Maharaj, M., Lynch, SD., Howe, BJ and Melvil-Thompson, B. (1997). South African Atlas of Agro-hydrology and – Climatology. WRC Report No. TT 82/96, Water Research Commission, Pretoria, South Africa.	http://sarva2.dirisa.org/resources/documents/beeh/Section%2001.3%20SA%20Atlas%20Term.pdf
		1.1	Water Shortage	This parameter was based on the DWS All Towns Reconciliation studies. Where no All Towns reconciliation data existed, WARMS Registered Surface Water Use and WR2012 runoff was used to calculate the average monthly net water depletion (Use/naturalised Runoff). This data was then updated by revising the timeframes associated with the different risk levels allocated based on time that has passed since the publication of the different All Towns reports.	Department of Water and Sanitation Cleaned WARMS data and summarised All Towns study data WR 2012 Data	https://www6.dwa.gov.za/DocPortal/Attribute_search.aspx https://www.dwa.gov.za/projects/warms/ http://waterresourceswr2012.co.za/
		1.2	Baseline Water Stress	See Global Documentation on Indicators, Sources and Description		
		1.3	Blue Water Scarcity	See Global Documentation on Indicators, Sources and Description		

Risk type	Risk category	#	Risk indicator	Description	Source	Link
		1.4	Projected Change in Water Discharge	A ratio of projected future over present change in water discharge was calculated from modelled present (1976 – 2005) and future (2016 – 2045) accumulated streamflow. The ratios were upscaled from quinnary to quaternary scale by accumulating the scores per the third (last) quinnary in each quaternary. A decrease in water discharge is indicated by values less than one, whilst an increase in discharge is indicated as any value greater than one.	Schulze, RE and Schutte, S. (2019). Projected changes in design streamflows in South Africa with climate change. Schulze and Associates, PMB, RSA.	
		1.5	Estimated Drought Occurrence	The historical occurrence of drought was generated using two input components, droughts occurring in the last 3 years and the variation in annual rainfall over the last 50 years. These were used to balance the impact of a changing climate where the current situation is seen as more representative of the future. To this end, the Agricultural Research Council's SPI 36 month data was used to identify areas with precipitation deficits over the last 3 years. The coefficient of variation of annual rainfall for each quaternary catchment data was extracted from Roland Schulze's Atlas of South African Agro hydrology and Meteorology. The two datasets were combined using the formula Drought Risk score = ((SPI36 x 2) + CoVar)/3	Schulze, RE., Maharaj, M., Lynch, SD., Howe, BJ and Melvil-Thompson, B. (1997). South African Atlas of Agro-hydrology and – Climatology. WRC Report No. TT 82/96, Water Research Commission, Pretoria, South Africa.	https://www.arc.agric.za/Pages/Home.aspx
		1.6	Projected change in Drought Occurrence	Six global circulation models were used in determining the future climate projections (between the years 1995 -2064). This data uses a Standard Precipitation Index (SPI) which characterises the extent and severity and duration of rainfall events (i.e. - drought and + floods) across the country. A maximum area approach was used to assign an SPI value per quaternary where the grid value which occupied the biggest area in the catchment was used as the assigned value.	Beraki, A. (2019). Green Book – The Impact of Climate Change on Drought. Technical report, Pretoria: CSIR.	https://www.greenbook.co.za/
	2. Flooding	**2.1**	Estimated Flood Occurrence	The 3 day 50 year flood was selected as the most appropriate flood form. Historical climate data acquired from 1950-1999 (rainfall, max/min temperature etc.), was used to model baseline streamflow using the ACRU hydrological model. Due to the physiographical diversity of the quaternaries, modelling was downscaled to quinnary level to adequately capture hydrological responses. The results were later scaled up to quaternary level.	Schulze, RE and Schutte, S. (2019). Projected changes in design streamflows in South Africa with climate change. Schulze and Associates, PMB, RSA.	
		2.2	Projected Change in Flood Occurrence	Flooding events were modelled using the CORDEX GCMs (Schulze and Schutte, 2019), for the present to intermediate future (30 years). The (means) GCMs with the highest predicted increases in flood events was selected as the indicator future flood occurrence. The expected changes are expressed as a ratio between present and intermediate future flood events (either greater than or less than 1, where anything greater indicates an	Schulze, RE and Schutte, S. (2019). Projected changes in design streamflows in South Africa with climate change. Schulze and	

Risk type	Risk category	#	Risk indicator	Description	Source	Link
				increase in potential floods). The 3 day 50 year return period was selected as an all-encompassing indicator highlighting the greatest impact.	Associates, PMB, RSA.	
	3. Water Quality	**3.1**	Surface Water Quality Index	The Automated Land-based Activity Risk assessment Method (ALARM) is a spatial tool inspired to model diffuse and point source pollution across a watershed. The key data inputs into ALARM are the 2020 National Land cover and the national quaternary catchment boundaries. The development of water quality per quaternary is generated through a series of weighted calculations based on the land use.	Department of Water Affairs (DWA). (2014). Assessing the Impact of Land-based Activities on Water Resources: User Manual for the Automated Land-based Activity Risk Assessment Method version 1.01. No. WP 10255).	https://egis.environment.gov.za/data_egis/data_download/current
	4. Ecosystem Services Status	**4.1**	Threat to Freshwater Biodiversity	Various classes from the National Biodiversity Assessment (2019) was used to determine the threat to freshwater biodiversity.	Skowno, A.L., Poole, C.J., Raimondo, D.C., Sink, K.J., Van Deventer, H., Van Niekerk, L., Harris, L.R., Smith-Adao, L.B., Tolley, K.A., Zengeya, T.A. and Foden, W.B., 2019. National biodiversity assessment 2018: the status of South Africa's ecosystems and biodiversity. Synthesis Report. South African National Biodiversity Institute, Pretoria.	http://biodiversityadvisor.sanbi.org/planning-and-assessment/national-biodiversity-assessment-nba-2018/
		4.2	Catchment Ecosystem Services Degradation Level	The latest (2020) National Land cover was reclassified into 3 categories namely (i) Untransformed (1): Water bodies, natural grassland / bushland / forest / shrub etc. (ii) Soft transformed (2): All forms of agriculture / orchards / plantations / small holdings (iii) Hard transformed (3): Mines, built-up urban areas (impermeable surfaces) The area of each category was calculated per quaternary catchment and this figure was converted to a percentage of the catchment. The transformation index score for each quaternary was then calculated using the following equation: ((Percentage Hard Transformed x 2) + (Percentage Soft Transformed))/3	DEA National Landcover (2020)	https://egis.environment.gov.za/data_egis/data_download/current
		4.3	Projected Impacts on Freshwater Biodiversity	See Global Documentation on Indicators, Sources and Description		
Regulatory Risk	**5. Enabling Environment**	**5.1**	Water Strategy	DWS All Towns strategy in place = 1. No strategy = 5	Department of Water and Sanitation All Towns Study	http://www6.dwa.gov.za/AllTownsRecStrat_NP/ReportsandDocuments.aspx

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Risk type	Risk category	#	Risk indicator	Description	Source	Link
		5.2	Freshwater Law Status (SDG 6.5.1)	See Global Documentation on Indicators, Sources and Description		
		5.3	Enabling Environment	If a Catchment Management Agency was established then this indicator was given a value of 1, otherwise for catchments with no formal CMAs the value was 5.	Department of Water and Sanitation All Towns Study	http://www6.dwa.gov.za/AllTownsRecStrat_NP/ReportsandDocuments.aspx
	6. Institutions & Governance	**6.1**	Government Performance Index	A layer has been generated using the Good Governance Africa 2019 Government Performance Index (GPI) and converting this to a quaternary catchment layer. This has been done by intersecting the quaternary catchment boundaries with the municipality boundaries and calculating the area of each quaternary catchment which falls in each municipality.	Good Governance Africa (2019)	https://www.polity.org.za/article/good-governance-africa-2019-government-performance-index-2019-04-29
		6.2	Freedom in the World Index	See Global Documentation on Indicators, Sources and Description		
		6.3	Stakeholder Platform	Quaternary catchment layer which differentiates between those areas with a functioning CMA or Proto CMA and those areas without one.	Department of Water and Sanitation Quayle *et al.* (2020). State of Strategic Water Source Areas – Monitoring and Reporting Framework and Information Platform: Status Quo Interim Report. Institute of Natural Resources. South Africa.	http://www4.dwa.gov.za/2012%20WMA/default.aspx https://www.researchgate.net/publication/344781258_STATE_OF_STRATEGIC_WATER_SOURCE_AREAS_-_Monitoring_and_Reporting_Framework_and_Information_Platform_STATUS_QUO_REPORT_INTERIM_REPORT/link/5f8fd2eda6fdccfd7b71e9a0/download

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Risk type	Risk category	#	Risk indicator	Description	Source	Link
	7. Management Instruments	**7.1**	Enforcement of Water-related Legal Framework	The 2021 Municipal Strategic Self-Assessment of Water Services (MuSSA) data set was utilised to generate a layer reflecting the percentage of local municipality's that are vulnerable / at risk of not fulfilling their water services function as a result of the condition of infrastructure. In order to spatially convert this data to quaternary catchment scale, this layer was intersected with the quaternary catchments of South Africa.	Department of Water and Sanitation	https://static.pmg.org.za/200303MuSSA_Report.pdf
		7.2	Groundwater Monitoring Data Availability and Management	See Global Documentation on Indicators, Sources and Description		
		7.3	Density of Runoff Monitoring Stations	The density of runoff monitoring was generated using the DWS list of current / operational gauging weirs across the country. Weir locations were plotted on tertiary catchment boundaries and the total number of weirs per catchment calculated. The density of weirs was calculated as kilometre of river per weir. The figure for each tertiary parent catchment was then allocated down to each quaternary catchment within it.	Department of Water and Sanitation	http://www.dwa.gov.za/iwqs/wms/data/000key.asp
	8. Infrastructure & Finance	**8.1**	Access to Safe Drinking Water	The 2016 Community Survey data set was utilised to generate a layer reflecting the percentage of people within each local municipality that do not have access to a piped water supply. This layer was intersected with the meso-zone spatial data (CSIR Geospatial Analysis Platform) which contains population data from the 2011 census. The relevant percentage was then applied to the total population of each meso-zone. This value was aggregated up to quaternary catchment scale and the summed values for each quaternary catchment ranked as a percentile. The percentile was then multiplied by five to get a score out of 5.	Stats SA 2016 Community Survey	www.statssa.gov.za
		8.2	Access to Sanitation	The 2016 Community Survey data set was utilised to generate a layer reflecting the percentage of people within each local municipality that do not have access to sanitation (no flush toilets). The community survey data layer was intersected with the meso-zone data which contains population data from the 2011 census. The relevant percentage was then applied to the total population of each meso-zone. This value was aggregated up to quaternary catchment scale and the summed values for each quaternary catchment ranked as a percentile. The percentile was then multiplied by five to get a score out of 5.	Stats SA 2016 Community Survey	www.statssa.gov.za

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		8.3	Financing for Water Resource Development and Management (SDG 6.5.1)	See Global Documentation on Indicators, Sources and Description		
Reputational Risk	**9. Cultural Importance**	**9.1**	Cultural/Religious Water Roles	Qualitative research on country level. The variables used included Ramsar wetlands of international importance and springs, which were deemed to be the most important, with cultural traditions and tourism activities associated with springs. Flagship Free Flowing Rivers were considered important (NFEPA) as well as well protected and moderately protected estuaries along the coastline. Formal Protected A and B as well as regular Free Flowing Rivers were considered important surrogates for this indicator. This layer was re-created using updated data from the NBA 2018 (Skowno *et al.* 2018).	RAMSAR, SADC HYDROGEOLOGICAL MAP, NFEPA and SANBI	http://biodiversityadvisor.sanbi.org/planning-and-assessment/national-biodiversity-assessment
	10. Biodiversity Importance	**10.1**	Freshwater Endemism	The National Freshwater Ecological Priority Area (NFEPA) data is used as a combined (endemism and richness) indicator of Biodiversity importance. The NFEPA Rivers database was aggregated up to quaternary level to determine the ecosystem services status of the country. This involved an intersection of the NFEPA layer together with the national quaternary layer.	Nel, J. L., Driver, A., Strydom, W. F., Maherry, A., Petersen, C., Hill, L., ... & Smith-Adao, L. B. (2011). Atlas of freshwater ecosystem priority areas in South Africa: Maps to support sustainable development of water resources.	http://bgis.sanbi.org/nfepa/project.asp
		10.2	Freshwater Biodiversity Richness	The National Freshwater Ecological Priority Area (NFEPA) data is used as a combined (endemism and richness) indicator of Biodiversity importance. The NFEPA Rivers database was aggregated up to quaternary level to determine the ecosystem services status of the country. This involved an intersection of the NFEPA layer together with the national quaternary layer.	Nel, J. L., Driver, A., Strydom, W. F., Maherry, A., Petersen, C., Hill, L., ... & Smith-Adao, L. B. (2011). Atlas of freshwater ecosystem priority areas in South Africa: Maps to support sustainable development of water resources.	http://bgis.sanbi.org/nfepa/project.asp
	11. Media Scrutiny	**11.1**	History of Protests	This indicator is based on the history of service delivery protests 1 January 2013 until 3 March 2014.	Institute for Security Studies	https://issafrica.org/
		11.2	Global Media Coverage	See Global Documentation on Indicators, Sources and Description		
	12. Conflict	**12.1**	Conflict News Events	See Global Documentation on Indicators, Sources and Description		

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Risk type	Risk category	#	Risk indicator	Description	Source	Link
		12.2	Hydro-political Likelihood	See Global Documentation on Indicators, Sources and Description		