WRPA-Zambia GIS database

Input data and resulting GIS layers
of the Water Resource Protection Area (WRPA) assessment for Zambia

Technical Documentation Version 1.0

prepared on behalf of WWF- Zambia
in collaboration with Water Resources Management Authority (WARMA)
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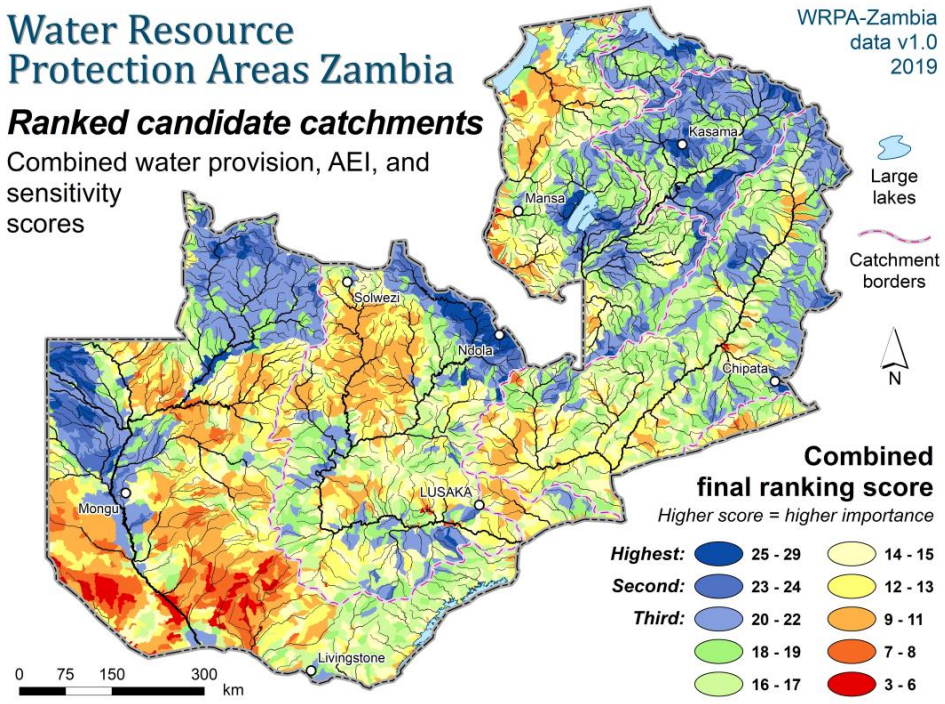

1. Background and introduction

In the Zambian Water Resources Management Act No. 21 of 2011, Water Resource Protection Areas (WRPAs) are defined as areas where special measures are necessary for the protection of a catchment, sub-catchment or geographic area. Three specific selection criteria are listed for the definition of WRPAs: (1) areas of high importance in providing water to users in a catchment; (2) areas of high aquatic ecological importance; and (3) areas that are particularly sensitive to use and anthropogenic impact.

Between 2017 and 2019, a national assessment was conducted, co-led by World Wide Fund for Nature (WWF) Zambia and the Water Resources Management Authority (WARMA) with the goal to develop a methodology and analytical framework to characterize each sub-catchment and river reach of Zambia for their importance regarding these three criteria, to rank them, and to prioritize WRPA candidate sites. **The Technical Documentation presented here describes the data layers that have been used or created during the national WRPA assessment, their format, and how they can be accessed using a Geographic Information System (GIS) software package.** The methods and results of the national WRPA assessment itself are fully described in a final report (WWF Zambia, WARMA, et al. 2019) and have been submitted for publication in a scientific journal (Lehner et al., under review). For more information please see the bibliography of this Technical Documentation or refer to https://wrpa-zambia.weebly.com.

The data and results of the national WRPA assessment are intended to support efforts to prioritize water resource protection areas, identify rivers with high conservation value, optimize decision making for infrastructure development, and inform concerted national strategies to maintain and restore important surface water catchment and rivers of Zambia. It is important to note that although a WRPA can relate to protecting both surface water and groundwater resources, it was agreed over the course of the supporting workshops—and in consultation with all parties involved—that the national assessment will only consider surface water resources, and that the results are intended to be used in combination with adequate groundwater protection strategies.

Besides the identification of candidate WRPAs, the extensive data preparation and processing steps of the national assessment led to the development of a dedicated database of hydro-environmental sub-catchment and river reach characteristics which are freely available as a stand-alone geospatial database termed **HydroATLAS-Zambia** (WWF-Zambia and Lehner 2020; for details and data see https://hydrosheds.org/hydroatlas-zambia). The goal of HydroATLAS-Zambia is to provide a broad user community with a standardized compendium of hydro-environmental attribute information for all catchments and rivers of Zambia at high spatial resolution. HydroATLAS-Zambia is a regionally customized version of the global HydroATLAS database (Linke et al. 2019). Version 1.0 of HydroATLAS-Zambia offers data for 51 hydro-environmental variables, partitioned into 259 individual attributes and organized in seven categories: hydrology; physiography; climate; land cover & use; soils & geology; anthropogenic influences; and Zambia-specific ecological information.

The WRPA-Zambia GIS database offers information in two related layers: **(1) information for all sub-catchment polygons**; and **(2) information for all river reach lines** of Zambia. The standardized format of the database ensures easy applicability while the inherent topological information supports basic network functionality such as identifying up- and downstream connections. The WRPA-Zambia GIS database is fully compatible with HydroATLAS-Zambia enabling users to conduct additional hydro-ecological assessments.

2. Geospatial units of sub-catchments and river reaches

The geospatial units of the WRPA-Zambia GIS database are identical to those of the HydroATLAS-Zambia database (https://hydrosheds.org/hydroatlas-zambia). They comprise either sub-basins (i.e. polygons; Figure 1) or river reaches (i.e. line segments; Figure 2). ***Note that the expression 'sub-basin' is used synonymously with 'sub-catchment'***. All sub-basin polygons and river reach lines

were originally extracted from the global hydrographic data framework HydroSHEDS (Lehner et al. 2008; Lehner and Grill 2013) at a grid resolution of 15 arc-seconds (approx. 500 m at the equator). For more information on HydroSHEDS please refer to https://www.hydrosheds.org.

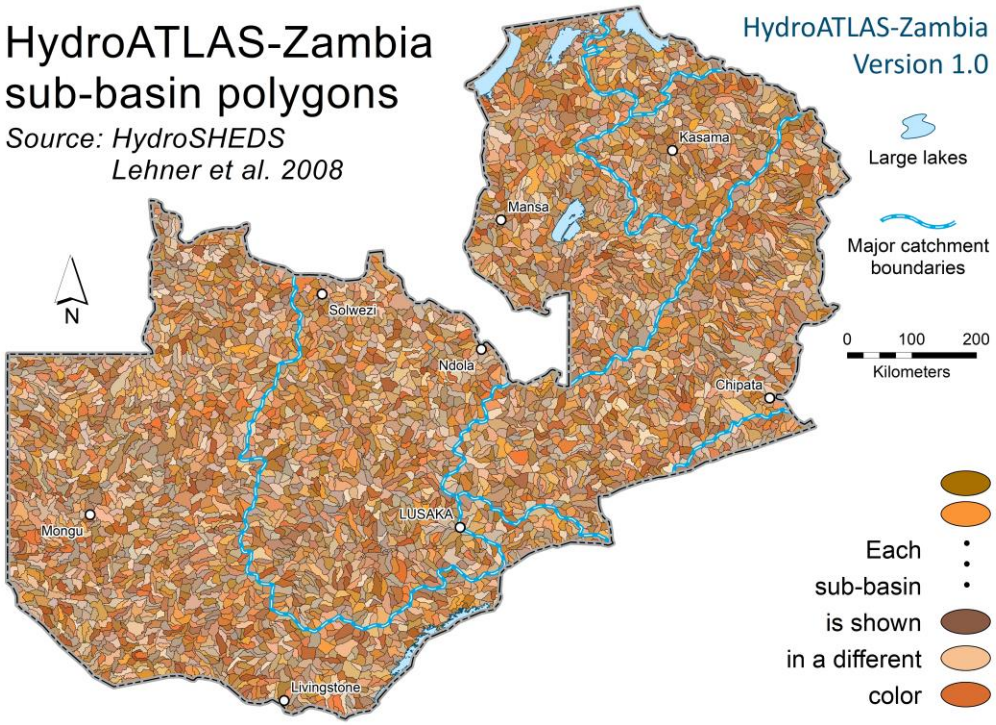

Figure 1: Sub-basin delineation of HydroATLAS-Zambia, which is also used in the WRPA-Zambia GIS database.

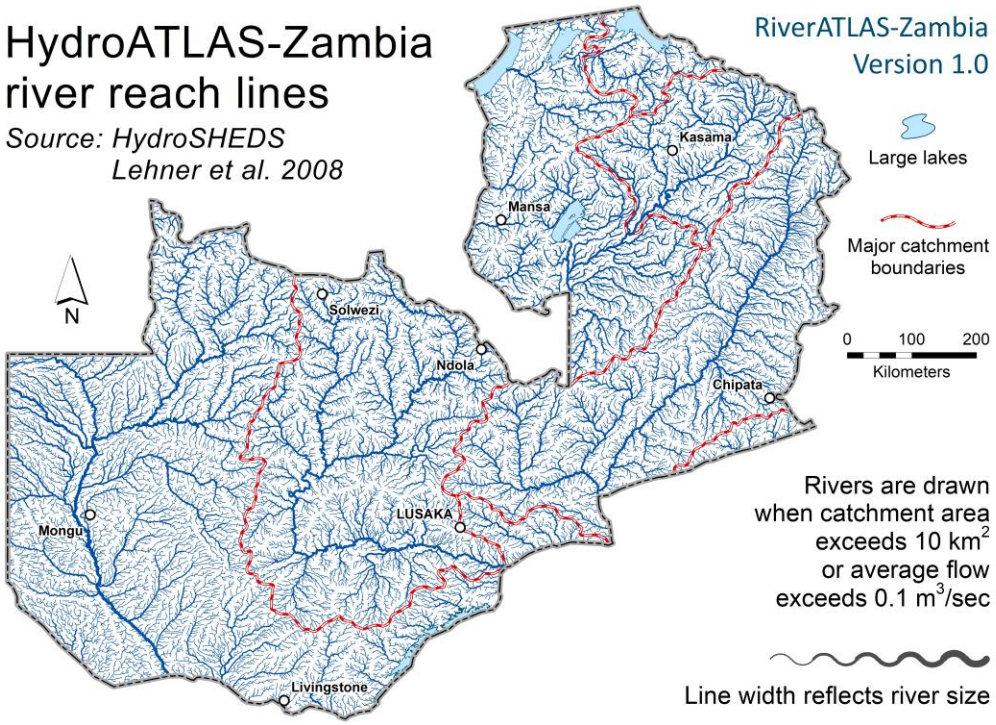

Figure 2: River reach delineation of HydroATLAS-Zambia, which is also used in the WRPA-Zambia GIS database.

The WRPA-Zambia GIS database contains two layers: **WRPA_Zambia_Basins** provides 5,539 individual polygons (sub-catchments) for Zambia with an average area of 141.7 km² (std. dev. 77.7 km²) covering a total area of 785,057 km² (Figure 1). **WRPA_Zambia_Rivers** encompasses a total of 36,099 individual line segments (river reaches) within Zambia with an average length of 4.8 km (std. dev. 4.0 km), totaling 172,871 km of river network (Figure 2).

It should be noted that the spatial extent of the provided GIS files goes beyond Zambia and includes the entire Zambezi Basin and portions of the upper Congo. This ensures that hydrological connections to up- and downstream parts of catchments remain intact and can be used in analyses that require these connections. All sub-basins and river reaches are flagged to be within or outside of Zambia. The WRPA ranking of rivers was only performed for reaches within Zambia that were also included in the statistical analyses of a Zambian free-flowing river assessment (Grill et al. 2017).

3. Joining the WRPA-Zambia GIS database with HydroATLAS-Zambia

Each layer of the WRPA-Zambia GIS database is provided with an individual attribute table that contains its full WRPA information (for details see section 4). The attribute tables also include the core fields from the HydroATLAS-Zambia database which offer general information on the geometry (e.g. area, length) and topology (e.g. next downstream object) of the sub-basins and river reaches in order to support basic analyses including navigation along up- or downstream connections.

If other HydroATLAS-Zambia attributes are required, the WRPA and HydroATLAS databases can be combined by **joining** the according attribute tables using the unique sub-basin or river reach IDs as the common field. After the join is performed, the user can remove duplicate fields (or other fields that are not required) and export the new layer as a permanently joined version (note that performing these steps will depend on the GIS of choice). Catalog files listing all available attributes of HydroALAS-Zambia are available at https://hydrosheds.org/hydroatlas-zambia.

4. Data format, projection, distribution and attribute fields

The WRPA-Zambia GIS database contains two spatial formats: sub-basins and river reaches:

- ***WRPA_Zambia_Basins_v10*** contains the sub-basin polygons
- ***WRPA_Zambia_Rivers_v10*** contains the river reach lines

Each of the two datasets is provided in both ESRI© Geodatabase and Shapefile formats; i.e., each is available either as a feature layer in a Geodatabase called 'WRPA_Zambia_Data_v10.gdb' or as a Shapefile in a folder called 'WRPA_Zambia_Data_v10_shp'.

The WRPA-Zambia GIS database is available electronically in compressed zip file format. To use the data files, the zip files must first be decompressed. Each zip file includes a copy of the Technical Documentation of the WRPA-Zambia GIS database. The data are projected in a Geographic Coordinate System using the World Geodetic System 1984 (GCS_WGS_1984). The attribute tables can also be accessed as stand-alone files in dBASE format which are included in the Shapefile format.

Tables 1 and 2 list all attribute fields contained in WRPA_Zambia_Basins and WRPA_Zambia_Rivers, respectively. Maps visualizing the main WRPA-specific attributes are presented in the Appendix.

Table 1: The WRPA_Zambia_Basins layer of sub-basins contains an attribute table which first provides a set of 13 core attributes (including IDs and geometric information) followed by 21 WRPA-specific attributes. Note that the 13 core attributes and their descriptions are slightly modified from the underpinning original dataset of HydroBASINS (for full documentation on HydroBASINS see https://www.hydrosheds.org/page/hydrobasins). Most WRPA-specific attributes are only available for sub-basins within Zambia (i.e. ZAMBIA_YN = 1).

Column	*Description*
HYBAS_ID	Unique basin identifier. The code consists of 10 digits. The first digit represents the region: 1 = Africa. The next 2 digits define the Pfafstetter level (10 for WRPA_Zambia_Basins). The next 6 digits represent a unique identifier within the HydroSHEDS network, and the last digit is set to 0 for WRPA_Zambia_Basins. *For more information please refer to the full documentation of HydroBASINS.*
NEXT_DOWN	HYBAS_ID of the next downstream polygon. This field can be used for navigation (up- and downstream) within the river network. The value '0' indicates a polygon with no downstream connection (i.e., the last polygon draining into the ocean or into an inland sink).
MAIN_BAS	HYBAS_ID of the most downstream polygon in the river basin, i.e. its outlet. This field can be used to identify the entire river basin that a polygon belongs to (by querying all records that show the same ID in the MAIN_BAS field).
DIST_MAIN	Distance along the river network from polygon outlet to the most downstream sink, i.e. to the outlet of the main river basin, in kilometers. The most downstream sink or outlet is that of the main basin, i.e. either the outlet at the ocean, or the final sink of an endorheic (inland) depression which forms its own basin.
SUB_AREA	Area of the individual polygon (i.e. sub-basin), in square kilometers.
UP_AREA	Total upstream area, in square kilometers, calculated from the headwaters to the polygon location (including the polygon).
PFAF_ID	The Pfafstetter code (at level 10 for WRPA_Zambia_Basins). *For more information please refer to the full documentation of HydroBASINS.*
ENDO	Indicator for endorheic (inland) basins without surface flow connection to the ocean: 0 = not part of an endorheic basin; 1 = part of an endorheic basin; 2 = sink (i.e. most downstream polygon) of an endorheic basin.
COAST	Indicator for lumped coastal basins: 0 = no; 1 = yes. Coastal basins represent conglomerates of small coastal catchments that drain into the ocean between larger river basins.
ORDER	Indicator of river order (classical ordering system): order 1 represents the main stem river from sink to source; order 2 represents all tributaries that flow into a 1st order river; order 3 represents all tributaries that flow into a 2nd order river; etc.; order 0 is used for conglomerates of small coastal catchments.
SORT	Indicator showing the record number (sequence) in which the original polygons are stored in the database (i.e. counting upwards from 1 in the original global database). The original polygons are sorted from downstream to upstream. This field can be used to sort the polygons back to their original sequence or to perform topological searches.

ZAMBIA_YN	Binary indicator showing values of 1 or 0 (yes/no) where 1 identifies all polygons that are part of Zambia (i.e., polygons that are fully or partially within Zambia). This field can be used to query and/or extract those polygons that are needed for analyzing data at a Zambian extent.
ZAM_CATCH	Unique identifier used to assign each polygon to one of the six major catchments as defined by WARMA: 1 = Zambezi; 2 = Kafue; 3 = Luangwa; 4 = Luapula; 5 = Chambeshi; 6 = Lake Tanganyika. The value '0' is used for all other polygons. Note that values are also assigned to polygons outside the national boundary of Zambia if they form part of the respective catchment (e.g., all polygons of the Zambezi Basin).
WRPA-specific attributes	
Runoff_mm	Long-term (1971-2000) average land surface runoff, in millimeters per year, as provided by HydroATLAS-Zambia v1.0.
Elev_m	Average sub-basin elevation above sea level, in meters, as provided by HydroATLAS-Zambia v1.0.
Slope_deg	Average sub-basin hillslope, in degrees, as provided by HydroATLAS-Zambia v1.0.
Eros_kha	Average sub-basin soil erosion, in kg per ha per year, as provided by HydroATLAS-Zambia v1.0. Original soil erosion estimates are provided by Borrelli et al. (2017).
Pop_count	Total number of people in sub-basin, as provided by HydroATLAS-Zambia v1.0.
Dam_count	Total number of dams in sub-basin, as provided by HydroATLAS-Zambia v1.0.
Dist_out	Distance to the outlet of the major Zambian catchment (see ZAM_CATCH), in kilometers. The outlet location is defined as either the end of the catchment (Kafue, Luangwa) or at/near the location where the catchment leaves Zambia (Zambezi, Luapula, Tanganyika); the Chambeshi catchment was assigned the same outlet as the Luapula catchment as they form one functional unit.
Pop_dn	Number of people living along downstream rivers. To calculate this number, the flow connection of every land pixel was traced along the river network counting the number of people that are located along the respective downstream rivers within Zambia (populations outside Zambia were not taken into account), and the average number found within the sub-basin was used. People were assumed to live "along" a river if they reside within the small contributing watershed of each river reach. People count is based on the WorldPop database (Tatem 2017; data for the year 2015).
Dams_dn	Number of dams located on downstream rivers. The locations of 1,020 existing dams were provided by WARMA and WWF-Zambia (see WWF-Zambia, WARMA, et al. 2019 for details). The given point locations of dams were first snapped to the HydroSHEDS river network by allowing a maximum snapping tolerance of one 500 m pixel. Then, for every pixel in the landscape the number of dams located downstream of it was calculated and the maximum number found within the sub-basin was used.
AEI_ssoln	Summed solution of Aquatic Ecological Importance (AEI) assessment. The summed solution is the number of times a sub-basin has been selected to achieve the target conservation portfolio using the systematic conservation planning software Marxan (see WWF-Zambia, WARMA, et al. 2019 for details). Values range from 0 to 200, with higher values representing higher aquatic ecological importance.

Rank_run	Rank of runoff (Runoff_mm). Ranks were assigned from 1 to 10 by distributing all sub-basins into 10 classes using equal quantiles.
Rank_dist	Rank of distance from major catchment outlet (Dist_out). Ranks were assigned from 1 to 10 by distributing all sub-basins into 10 classes using equal quantiles.
Rank_topo	Rank of topography (based on UP_AREA and Slope_deg). Ranking values from 1 to 3 were assigned to sub-basins which have (1) less than 1000 km^2 upstream area and more than 1 degree average slope; (2) less than 1000 km^2 upstream area and more than 1.5 degree average slope; and (3) less than 500 km^2 upstream area and more than 2 degrees average slope.
Rank_head	Combined rank of headwaters (based on Rank_dist and Rank_topo). Ranking values from 1 to 10 were assigned by summing Rank_dist and Rank_topo values and capping the result at 10.
Rank_pop	Rank of downstream population (Pop_dn). Ranks were assigned from 1 to 10 by distributing all sub-basins into 10 classes using equal quantiles.
Rank_dams	Rank of downstream dams (Dams_dn). To provide a ranking, the number of downstream dams was standardized to a scale of 0 (no downstream dams) to 10 by capping the number at 10 (as only very few sub-catchments exceeded 10, with the maximum being 18).
Sum_prov	Sum of all individual water provision ranks (i.e. Rank_run + Rank_head + Rank_pop + Rank_dams). Possible values range from 3 to 40.
Rank_prov	Rank of water provision (Sum_prov). Ranks were assigned from 1 to 10 by distributing all sub-basins into 10 classes using equal quantiles.
Rank_AEI	Rank of Aquatic Ecological Importance (AEI) assessment results (AEI_ssoln). Ranks were assigned from 1 to 10 by distributing all sub-basins into 10 classes using equal quantiles, and 0 was assigned to sub-basins with a summed solution of 0.
Rank_eros	Rank of soil erosion (Eros_kha). Ranks were assigned from 1 to 10 by distributing all sub-basins into 10 classes using equal quantiles.
Rank_final	Combined final rank (i.e. Rank_prov + Rank_AEI + Rank_eros). Possible values range from 2 to 30.

Table 2: The WRPA_Zambia_Rivers layer of river reaches contains an attribute table which first provides a set of 16 core attributes (including IDs and geometric information) followed by 20 WRPA-specific attributes. Note that the 16 core attributes and their descriptions are slightly modified from the underpinning original dataset of HydroRIVERS (for full documentation on HydroRIVERS see https://www.hydrosheds.org/page/hydrorivers). Attributes related to the free-flowing river (FFR) assessment cover all of the Zambezi Basin. The ranking of rivers was only performed for reaches within Zambia that were also included in the statistical analyses of the FFR assessment (i.e. ZAMBIA_YN = 1 AND FFR_inc_yn = 1).

Column	*Description*
HYRIV_ID	Unique identifier for each river reach. The code consists of 8 digits. The first digit represents the region: 1 = Africa. The other 7 digits represent a unique identifier within the river network.
NEXT_DOWN	HYRIV_ID of the next downstream line segment. This field can be used for navigation (up- and downstream) within the river network. The value '0' indicates a line with no downstream connection (i.e., the last river reach draining into the ocean or into an inland sink).
MAIN_RIV	HYRIV_ID of the most downstream reach in the river basin, i.e. its outlet. This field can be used to identify the entire river network that belongs to this basin (by querying all records that show the same ID in the MAIN_RIV field).
LENGTH_KM	Length of the river reach segment, in kilometers.
DIST_DN_KM	Distance from the reach outlet, i.e., the most downstream pixel of the reach, to the final downstream location along the river network, in kilometers. The final downstream location is either the pour point into the ocean or an inland sink.
DIST_UP_KM	Distance from the reach outlet, i.e., the most downstream pixel of the reach, to the most upstream location along the river network, in kilometers. The most upstream location is the furthest upstream point from this reach on the watershed divide.
CATCH_SKM	Area of the catchment that contributes directly to the individual reach, in square kilometers. The catchment only relates to the reach itself, while the contributing area of all upstream reaches is not included (see next column).
UPLAND_SKM	Total upstream area, in square kilometers, calculated from the headwaters to the pour point (i.e., the most downstream pixel) of the reach.
ENDORHEIC	Indicator for endorheic (inland) basins without surface flow connection to the ocean: 0 = not part of an endorheic basin; 1 = part of an endorheic basin.
DIS_AV_CMS	Average long-term discharge estimate for the river reach, in cubic meters per second. *For more information please refer to the documentation of HydroRIVERS*.
ORD_STRA	Indicator of river order following the Strahler ordering system: order 1 represents headwater streams; when two 1st order streams meet, they form a 2nd order river; when two 2nd order rivers meet, they form a 3rd order river; etc.
ORD_CLAS	Indicator of river order following the classical ordering system (also called 'Hack's stream orders'): order 1 represents the main stem river from sink to source; order 2 represents all tributaries that flow into a 1st order river; order 3 represents all tributaries that flow into a 2nd order river; etc. This ordering system can be used to identify 'backbone' rivers, i.e., the main stem of a river from source to sink.

ORD_FLOW	Indicator of river order using river flow to distinguish logarithmic size classes: order 1 represents river reaches with a long-term average discharge ≥ 100,000 m^3/s; order 2 represents river reaches with a long-term average discharge ≥ 10,000 m^3/s and < 100,000 m^3/s; … order 9 represents river reaches with a long-term average discharge ≥ 0.001 m^3/s and < 0.01 m^3/s; and order 10 represents river reaches with a long-term average discharge < 0.001 m^3/s.
HYBAS_L10	HYBAS_ID of the corresponding sub-basin polygon of WRPA_Zambia_Basins in which the river reach resides (at Pfafstetter level 10).
ZAMBIA_YN	Binary indicator showing values of 1 or 0 (yes/no) where 1 identifies all river reaches that are part of Zambia (i.e., line segments that are fully or partially within Zambia). This field can be used to query and/or extract those river reaches that are needed for analyzing data at a Zambian extent.
ZAM_CATCH	Unique identifier used to assign each river reach to one of the six major catchments as defined by WARMA: 1 = Zambezi; 2 = Kafue; 3 = Luangwa; 4 = Luapula; 5 = Chambeshi; 6 = Lake Tanganyika. The value '0' is used for all other line segments. Note that values are also assigned to river reaches outside the national boundary of Zambia if they form part of the respective catchment (e.g., all river reaches of the Zambezi Basin).
WRPA-specific attributes	
Dischg_cms	Long-term (1971-2000) average river discharge, in cubic meters per second, as provided by HydroATLAS-Zambia v1.0.
Dis_lo_cms	Long-term (1971-2000) average river discharge of lowest flow month in year, in cubic meters per second, as provided by HydroATLAS-Zambia v1.0.
Dis_hi_cms	Long-term (1971-2000) average river discharge of highest flow month in year, in cubic meters per second, as provided by HydroATLAS-Zambia v1.0.
Sed_ld_tt	Sediment load, in thousand tons per year. Estimates were calculated by accumulating the upstream sum of all soil erosion amounts provided by the global soil erosion map of Borrelli et al. (2017) and accounting for natural sediment capture in lakes using trapping efficiencies. For more details see WWF-Zambia, WARMA, et al. (2019).
Sed_con_gl	Sediment concentration, in grams per liter. Estimates were calculated by dividing the annual estimated sediment load (Sed_ld_tt) by the annual average discharge (Dischg_cms).
Riv_len_km	Length of contiguous river (also called 'back-bone river'), in kilometers, from source to sink. The sink of a river is either the final outlet into the ocean or into a terminal land surface depression, or its confluence with a larger river of a higher river order (ORD_CLAS).
FFR_DOF	Degree of Fragmentation (DOF) index as calculated in the free-flowing river assessment. For more details see Grill et al. (2017). Values range from 0 to 100.
FFR_DOR	Degree of Regulation (DOR) index as calculated in the free-flowing river assessment. For more details see Grill et al. (2017). Values range from 0 to 100.
FFR_USE	Human water use index (USE) as calculated in the free-flowing river assessment. For more details see Grill et al. (2017). Values range from 0 to 100.

FFR_RDD	Road density index (RDD) as calculated in the free-flowing river assessment. For more details see Grill et al. (2017). Values range from 0 to 100.
FFR_URB	Urban development index (URB) as calculated in the free-flowing river assessment. For more details see Grill et al. (2017). Values range from 0 to 100.
FFR_CSI	Connectivity Status Index (CSI) for every river reach. The CSI was calculated through a weighted overlay of the individual indices (DOF, DOR, USE, RDD, URB) and quantifies connectivity between river reaches ranging from 0 (no connectivity) to 100 (full connectivity). For more details see Grill et al. (2017).
FFR_type	Type of river as calculated in the free-flowing river assessment (1 = free-flowing river, 2 = free-flowing stretch, 3 = non-free-flowing). For more details see Grill et al. (2017).
FFR_len_km	Length, in kilometers, of contiguous free-flowing river or free-flowing stretch. For more details see Grill et al. (2017).
FFR_inc_yn	Indicator whether reach was included in the free-flowing river (FFR) assessment of Zambia. *Note: while the individual river reach indices (DOF, DOR, USE, RDD, URB, CSI and type) were calculated for all reaches of the Zambezi Basin, rivers were removed from the final FFR statistical analyses if they were shorter than 10 km, showed an average annual flow of less than 1 m^3/s, or were in hot or cold deserts according to existing physiographic maps to exclude increasingly uncertain results of smaller rivers.*
Rank_FFR	Rank of free-flowing river status. To incorporate the results of the free-flowing river assessment into the WRPA assessment, a ranking scheme on a scale of 0 to 10 was developed and applied. For more details see WWF-Zambia, WARMA, et al. (2019).
Rank_sed_l	Rank of sediment load (Sed_ld_tt). Ranks were assigned from 1 to 10 by distributing all river reaches into 10 classes using equal quantiles.
Rank_sed_c	Rank of sediment concentration (Sed_con_gl). Ranks were assigned from 1 to 10 by distributing all river reaches into 10 classes using equal quantiles.
Rank_sed	Combined rank of sediment transport (i.e. average of Rank_sed_l and Rank_sed_c). Possible (rounded) values range from 1 to 10.
Rank_final	Combined final rank (based on Rank_FFR and Rank_sed). The final rank was calculated by multiplying Rank_FFR and Rank_sed which sets all non-FFR reaches to 0 and weighs all FFR scores by the scores of sediment transport. Possible values range from 0 to 100.

5. License, disclaimer and acknowledgements

5.1 License agreement

The WRPA-Zambia GIS database has been created as part of the national WRPA-Zambia assessment and is co-owned by the authors of the assessment. It is shared publicly and can be used for scientific, educational, and other non-commercial purposes. By downloading and using the data the user agrees to the terms and conditions of this license as outlined below.

5.2 Disclaimer of warranty

The WRPA-Zambia GIS database and any related materials contained therein are provided "as is" without warranty of any kind, either express or implied, including, but not limited to, the implied warranties of merchantability, fitness for a particular purpose, noninterference, system integration, or noninfringement. The entire risk of use of the data shall be with the user. The user expressly acknowledges that the data may contain some nonconformities, defects, or errors. The authors do not warrant that the data will meet the user's needs or expectations, that the use of the data will be uninterrupted, or that all nonconformities, defects, or errors can or will be corrected. The authors are not inviting reliance on these data, and the user should always verify actual data.

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In no event shall the authors be liable for costs of procurement of substitute goods or services, lost profits, lost sales or business expenditures, investments, or commitments in connection with any business, loss of any goodwill, or for any direct, indirect, special, incidental, exemplary, or consequential damages arising out of the use of the WRPA-Zambia GIS database and any related materials, however caused, on any theory of liability, and whether or not the authors have been advised of the possibility of such damage. These limitations shall apply notwithstanding any failure of essential purpose of any exclusive remedy.

5.4 Data citation

Citations and acknowledgements of the WRPA-Zambia GIS database should be made as follows:

> *WWF-Zambia, WARMA, Lehner B. (2020). WRPA-Zambia GIS database. Technical Documentation Version 1.0. Available at: https://wrpa-zambia.weebly.com.*

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6. References

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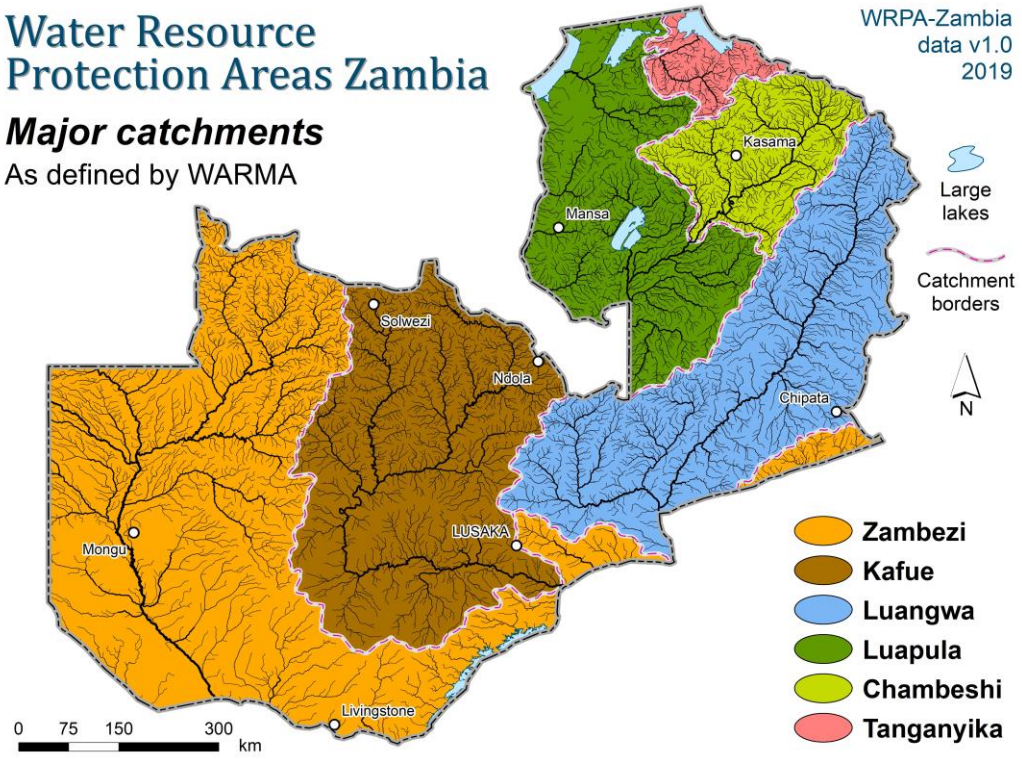
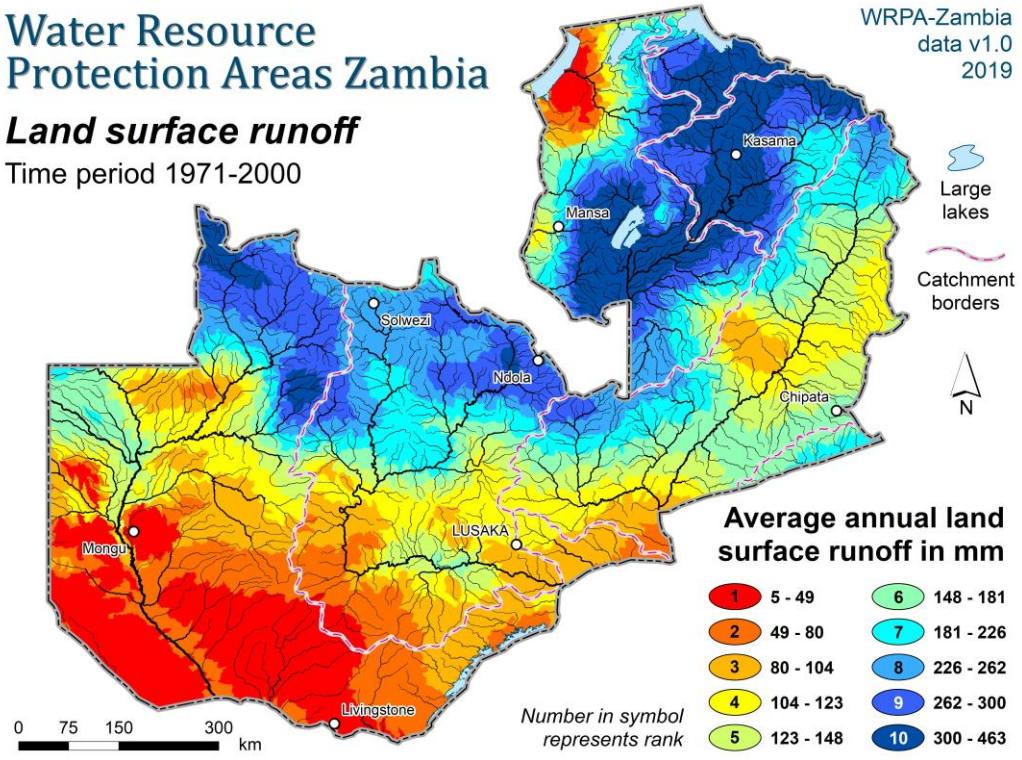
Appendix

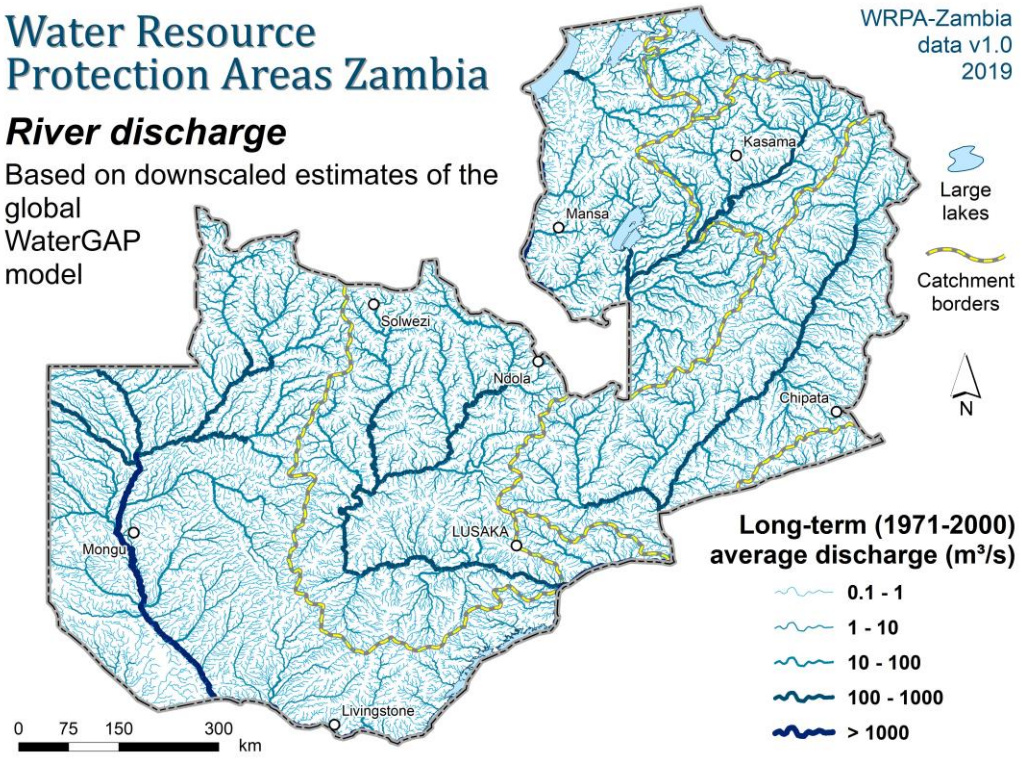
Maps visualizing WRPA-specific attributes and results



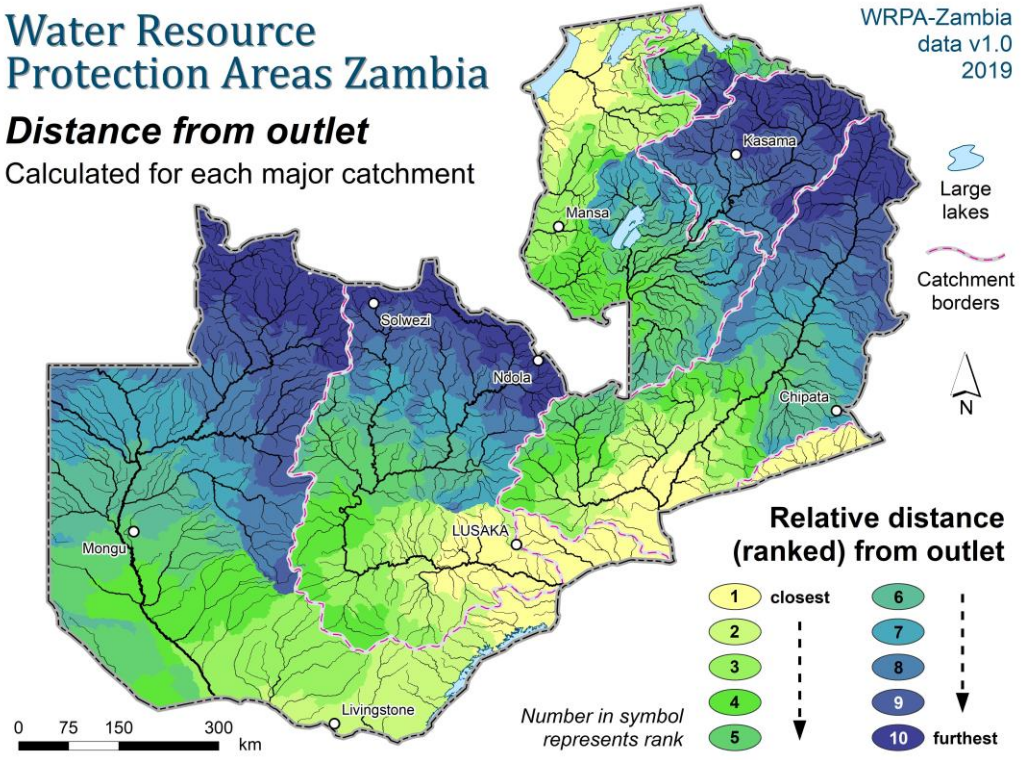
Map 1: Major catchments of Zambia.



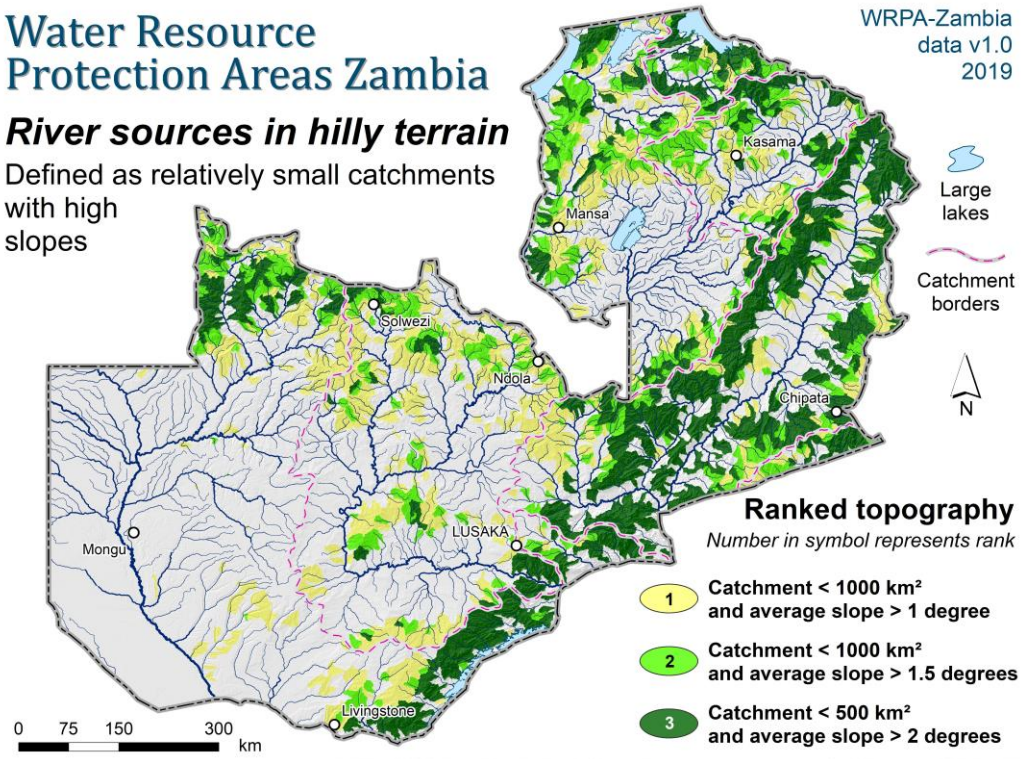
Map 2: Average land surface runoff.



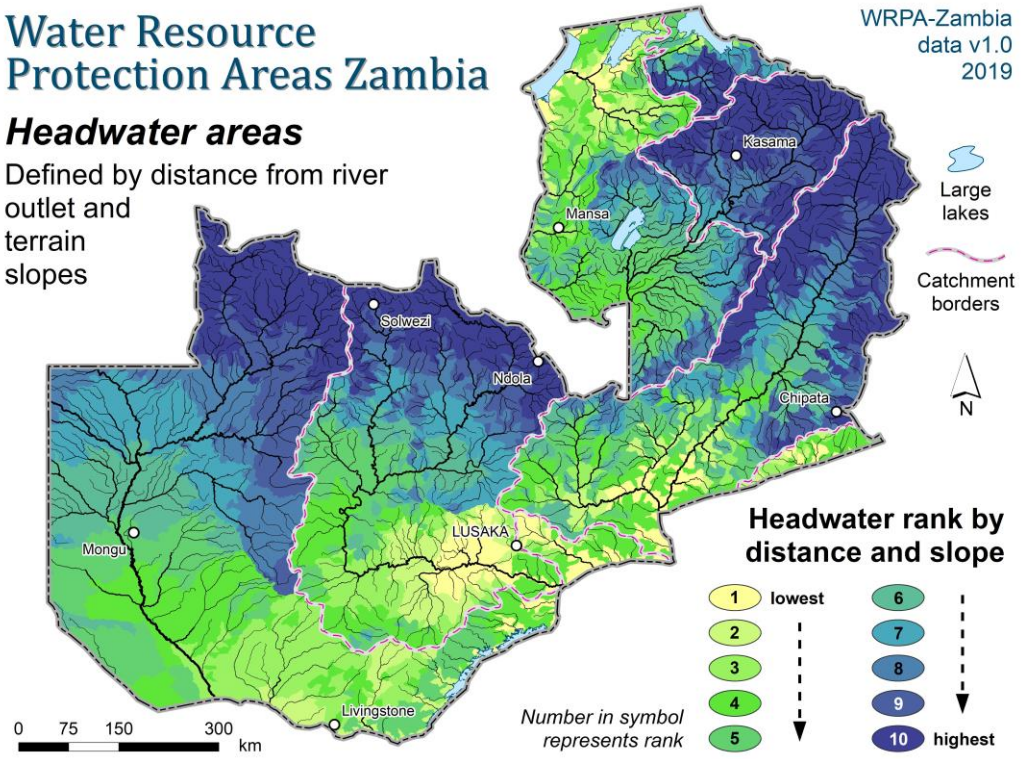
Map 3: Average river discharge.



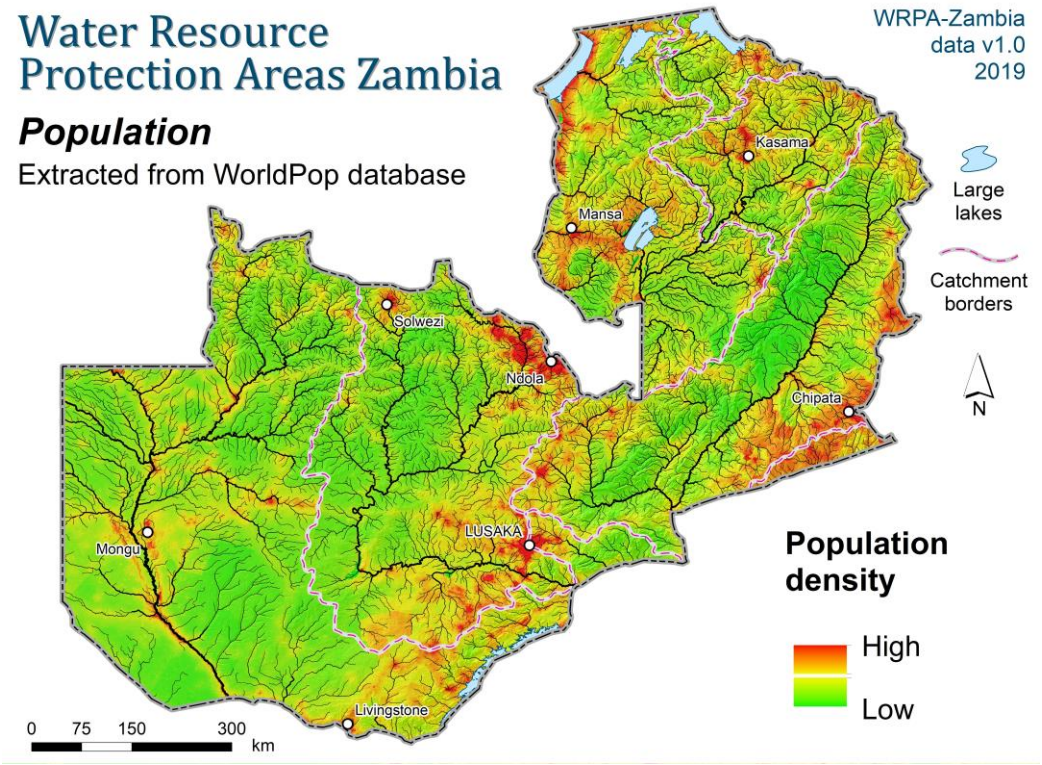
Map 4: Ranked distance from catchment outlet.



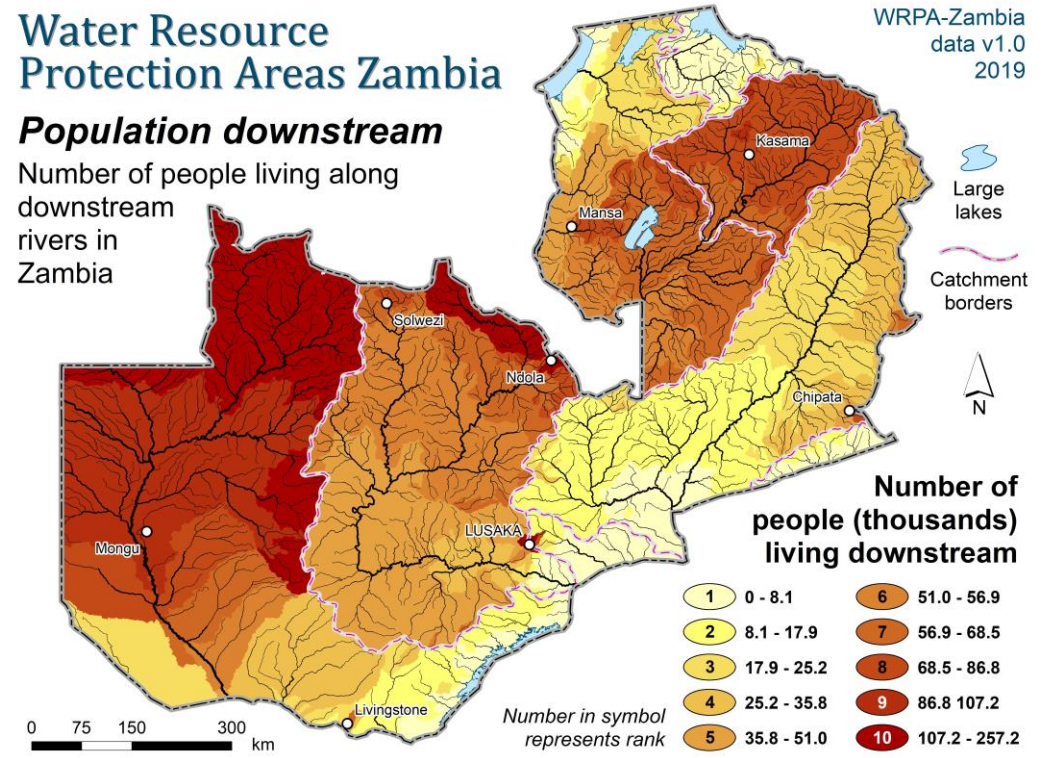
Map 5: Ranked river sources in hilly topography.



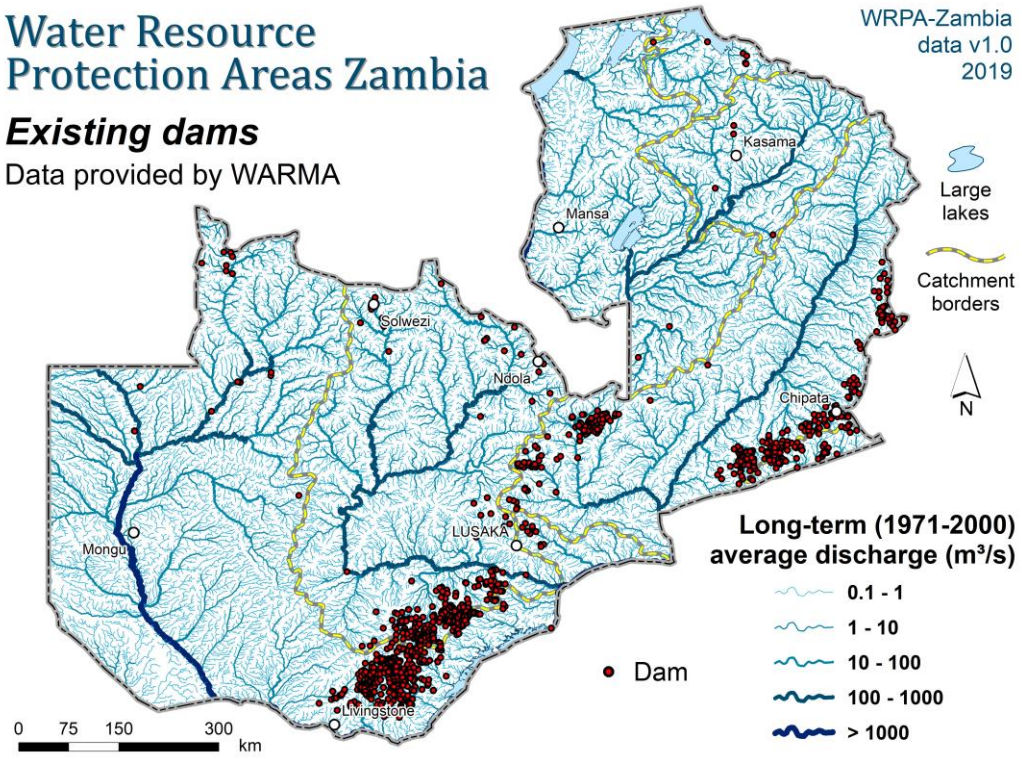
Map 6: Ranked headwater areas.



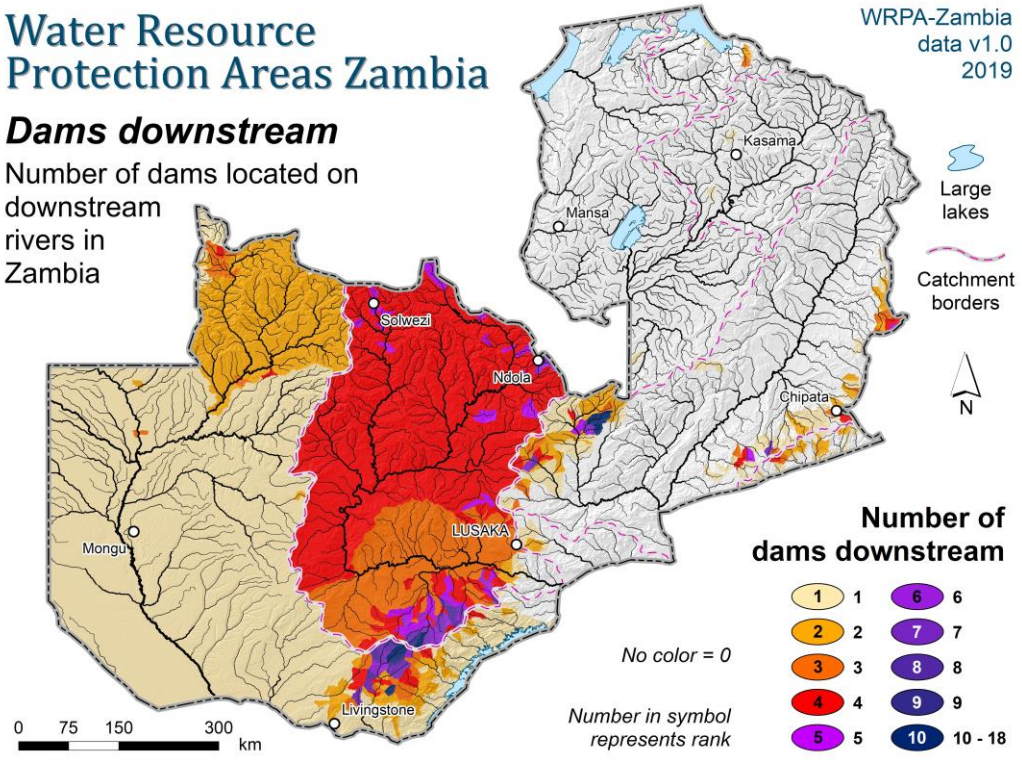
Map 7: Population based on WorldPop database.



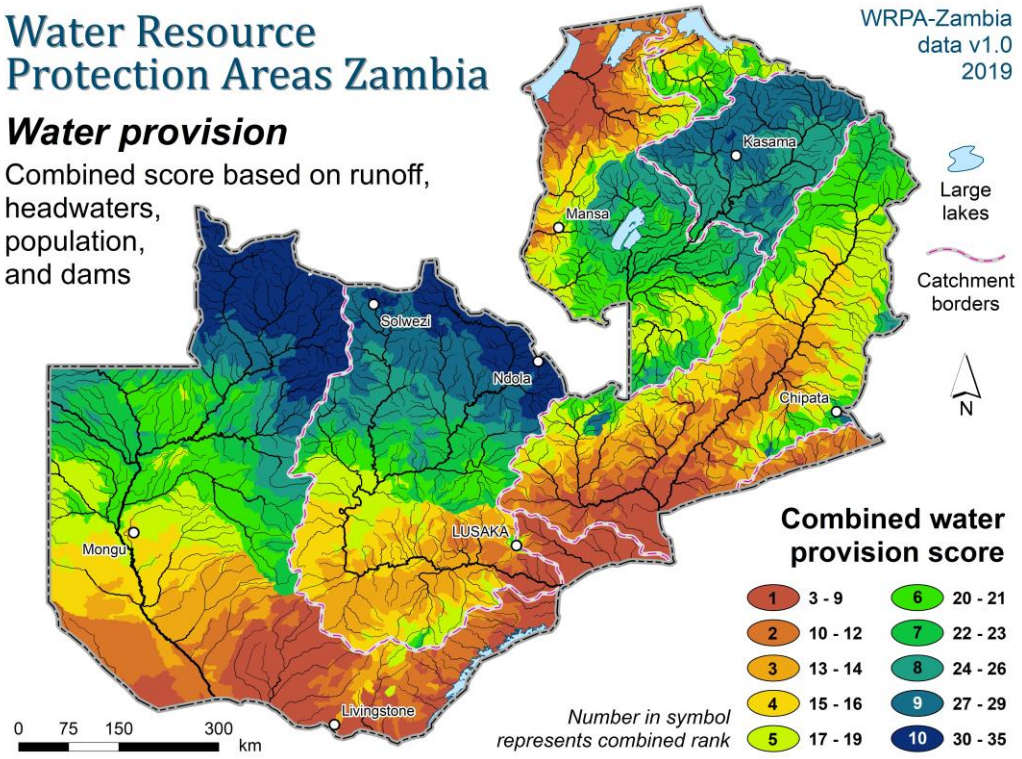
Map 8: Ranked number of people living downstream.



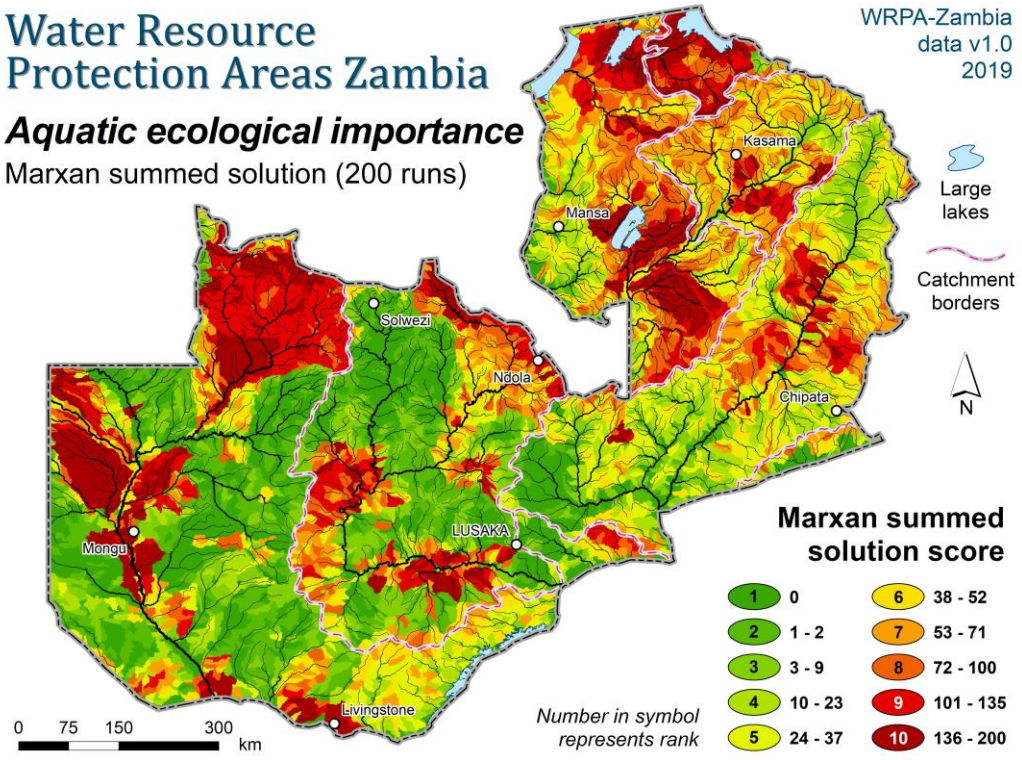
Map 9: Existing dams.



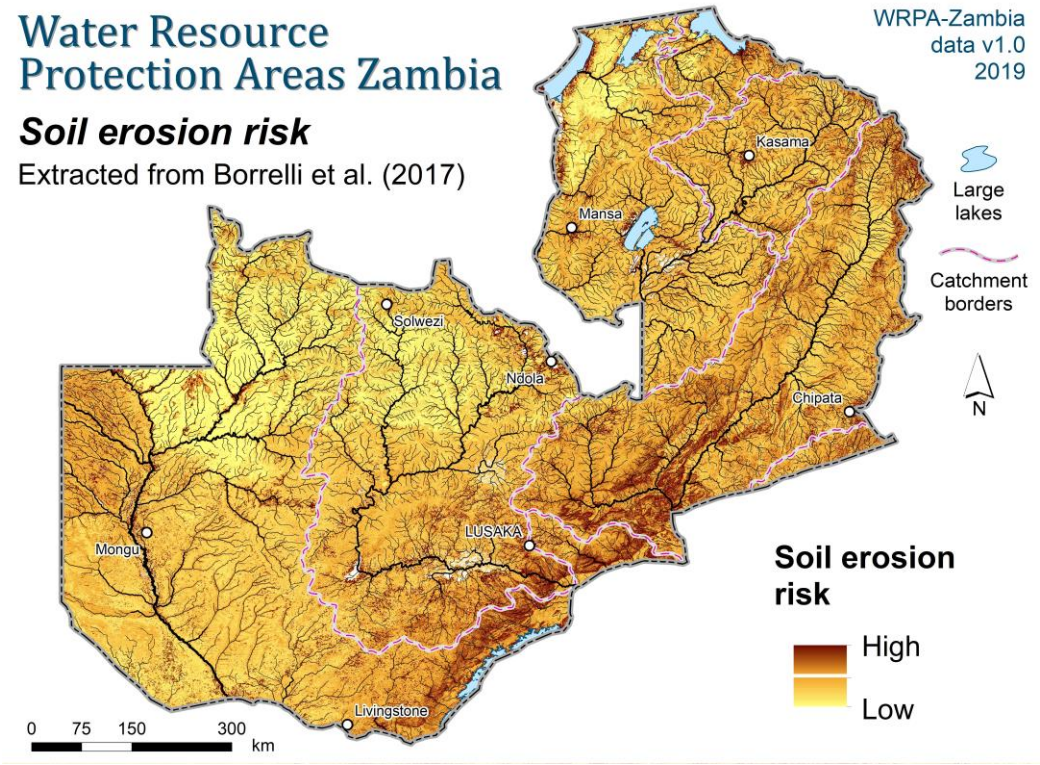
Map 10: Ranked number of dams downstream.



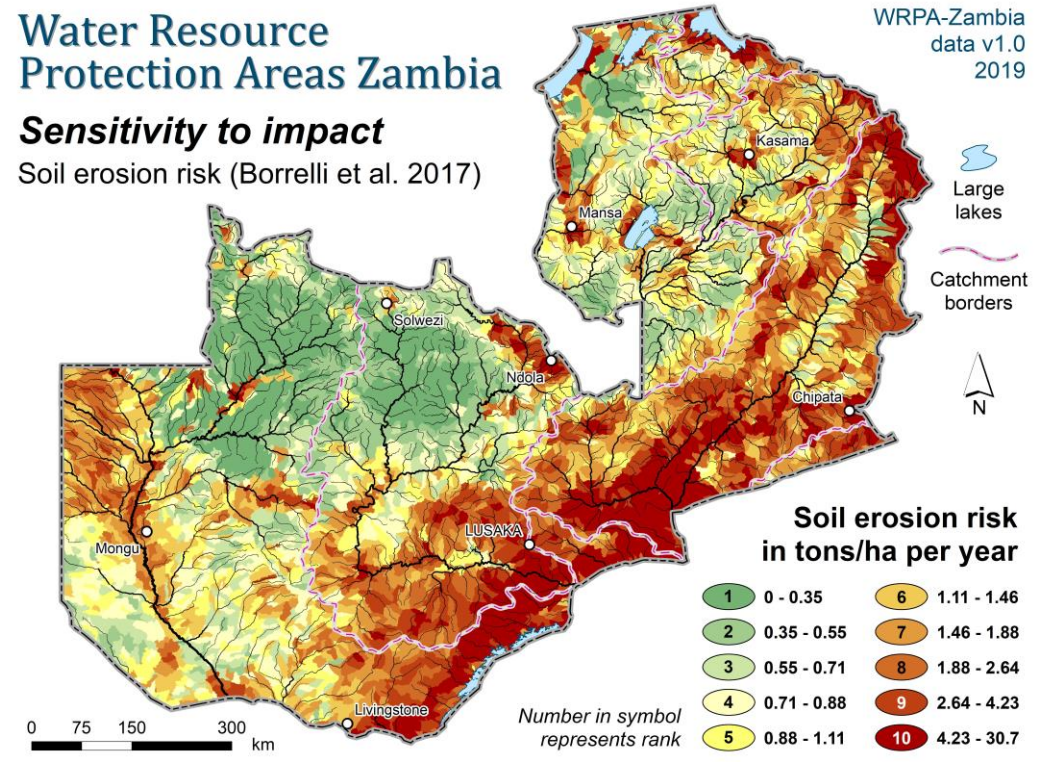
Map 11: Ranked score for water provision.



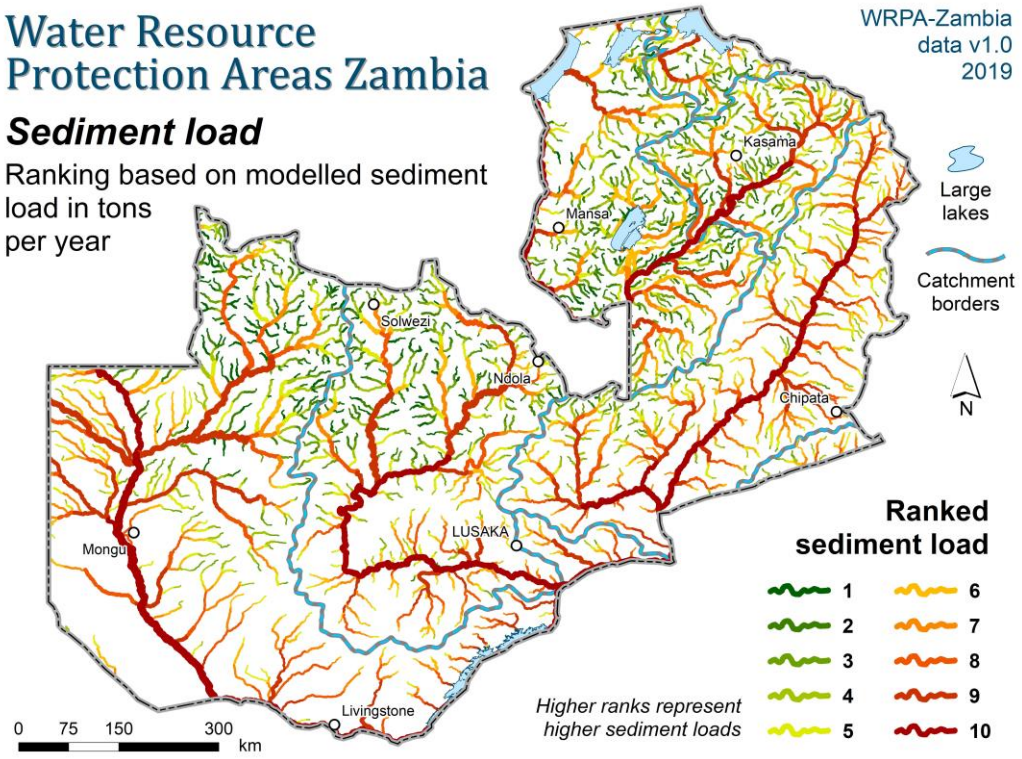
Map 12: Ranked score for aquatic ecological importance.



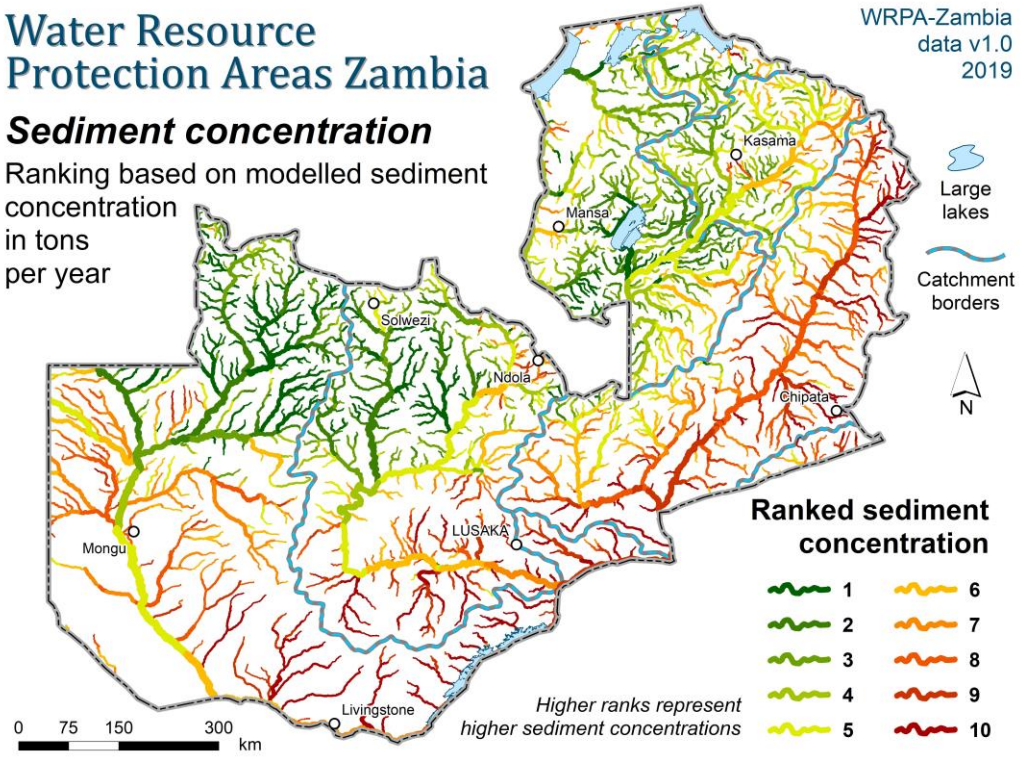
Map 13: Soil erosion risk based on global soil erosion map (Borrelli et al. 2017).



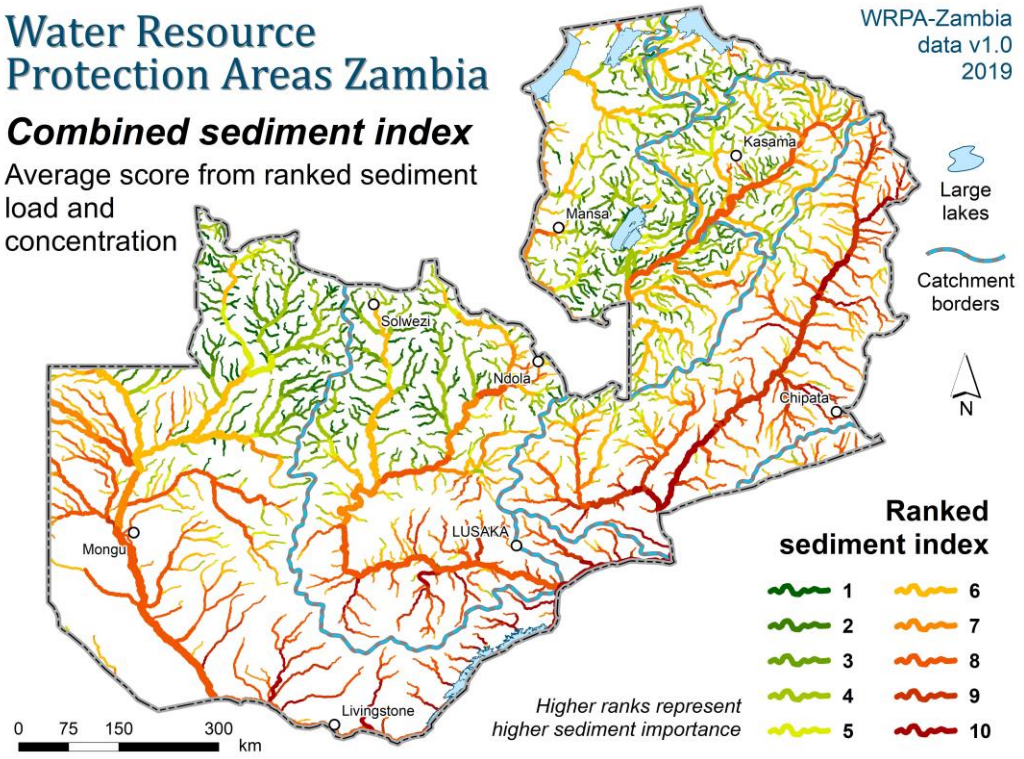
Map 14: Ranked score for sensitivity (soil erosion risk).



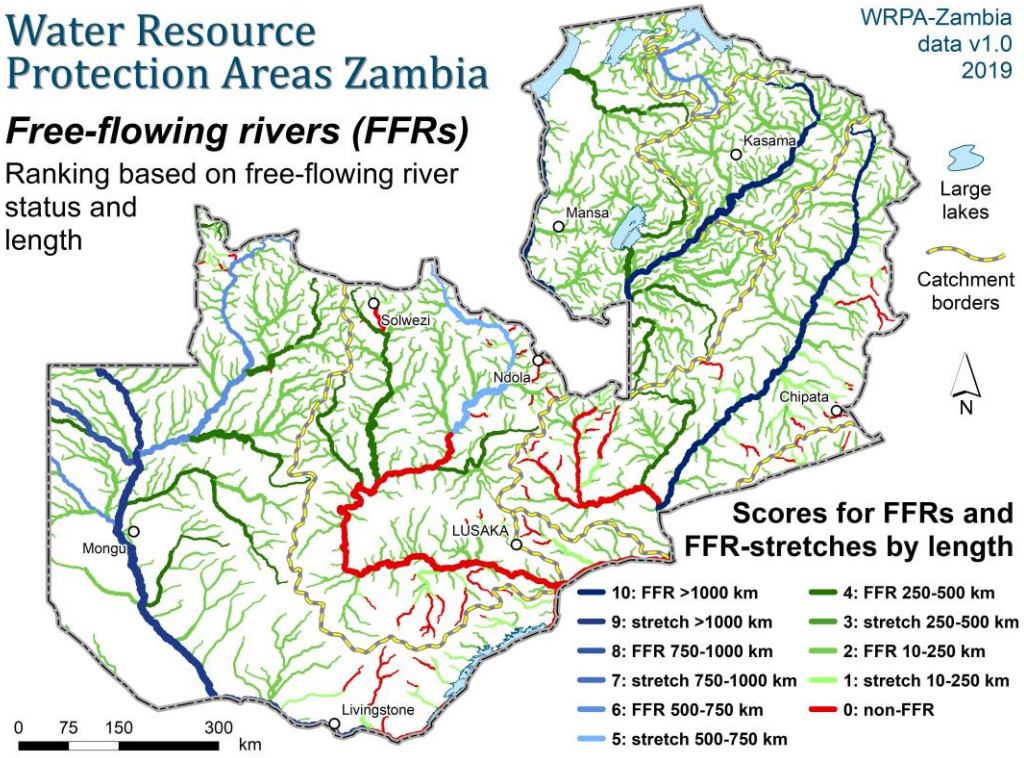
Map 15: Ranked sediment loads.



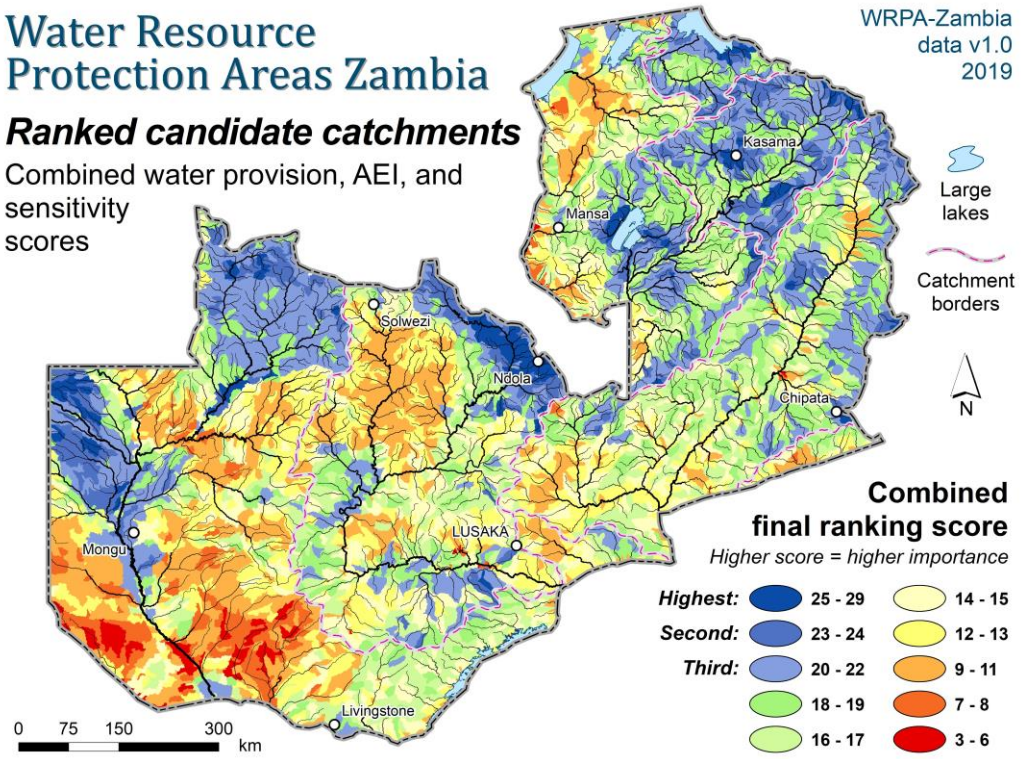
Map 16: Ranked sediment concentrations.



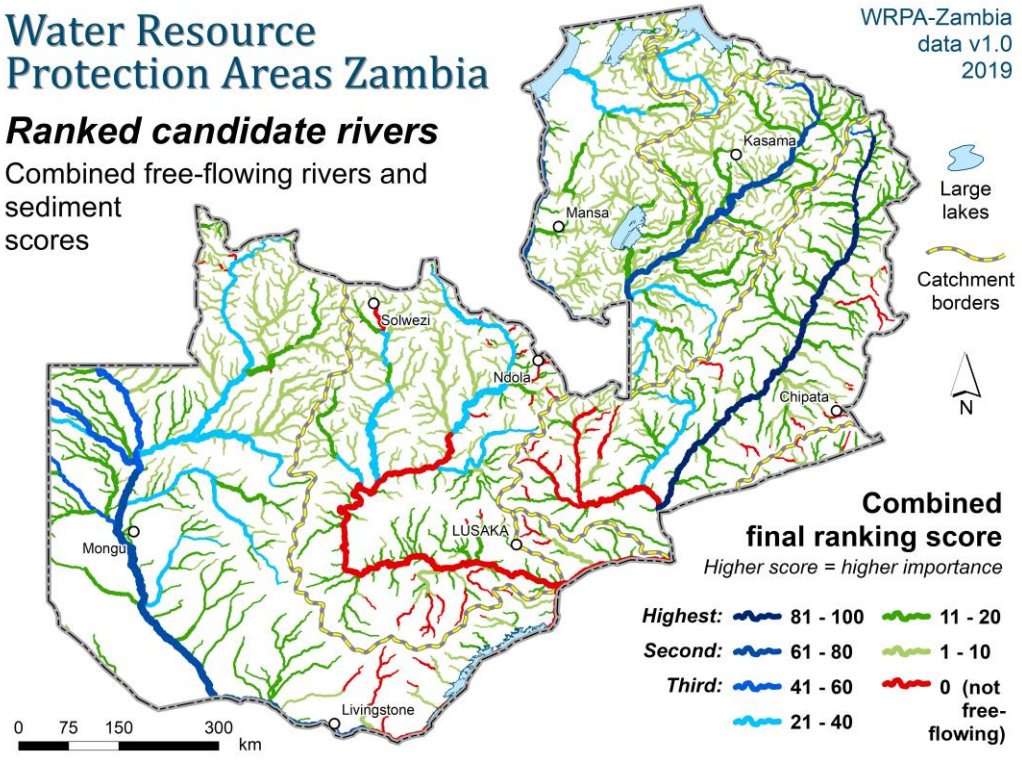
Map 17: Ranked score for combined sediment transport.



Map 18: Ranked score for free-flowing river status.



Map 19: Ranked final score of WRPA-Zambia assessment for sub-catchments.



Map 20: Ranked final score of WRPA-Zambia assessment for river reaches.