ORINOCO
RIVER BASIN
REPORT CARD
COLOMBIA

METHODOLOGY REPORT

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WWF - Colombia

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1 Overview

The Orinoco River's bi-national basin lies between Colombia and Venezuela, encompassing 830,000 km2. It is considered the third most important river system on earth containing a diverse array of wetlands, savannas, grasslands and forests including part of the Amazon biome. Biodiversity in this region is exceptional, with 17,420 plants species, 1,300 bird species, over 1,000 fish species, 250 mammals and 119 reptiles having been recorded to date.

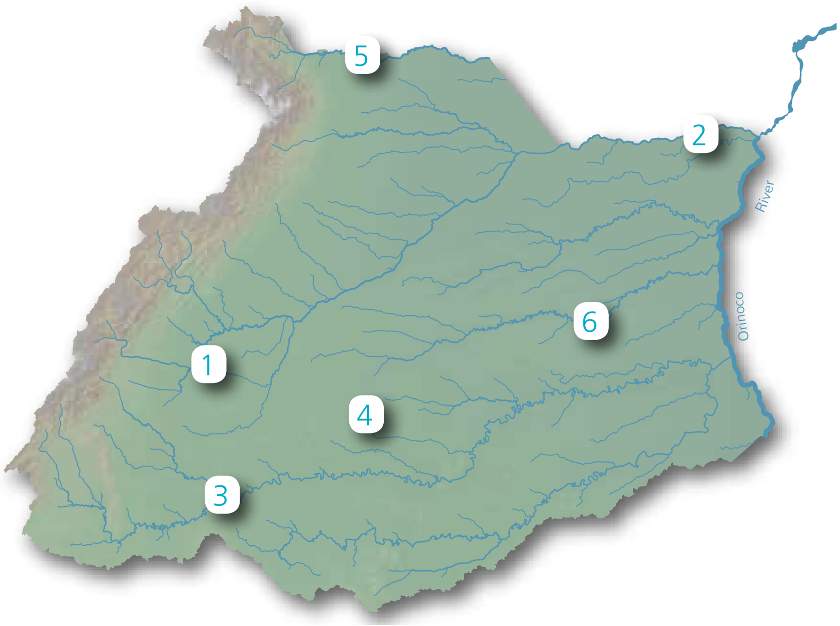
In recent years, the Colombian region of the Orinoco River has experienced rapid growth of agribusiness, livestock, and oil and gas activities. Increased demand for water and other ecosystem services to support economic development in the basin is likely to surpass natural supplies in the future if left unmanaged.

In order to enhance understanding and management of these threats, the World Wildlife Fund has invited stakeholders from various agencies and organizations to help develop a Basin Health Report Card for the Orinoco River in Colombia. This effort, in collaboration with the University of Maryland Center for Environmental Science and Humboldt Institute, brought together local and regional experts and stakeholders to develop basin health indicators, thresholds, and a reporting framework for a Orinoco River Report Card.

The report card aims to capture a snapshot of the ecological health of the Orinoco River Basin based on pre-defined indicators and goals, and to be able to track change over time in response to management actions and/or external pressures. This methodology report accompanies the Orinoco River Basin Report Card and outlines the technical methodology used to source chosen indicator data (Table 1-1), and calculate report card scores following several stakeholder workshops in 2015 and 2016 in Colombia, and subsequent reviews by technical stakeholders.

1.1 Stakeholder engagement in the Orinoco River Basin (Colombia)

Stakeholders throughout the Colombian portion of the Orinoco River Basin (149 representatives from 71 organizations) identified the most important values for the basin and determined key threats to these values during workshops for the sub-basins of the Meta, Bita, Guaviare, Arauca, Tomo, Tuparro, and Vichada between June 2015 and April 2016.



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1.2 Indicator Selection

The values and threats were grouped into the following categories: Biodiversity, Management & Governance, Ecosystems & Landscapes, Economy, People & Culture, and Water (Figure 1-1). Given that human health is a critical part of societal health within basins, indicators of human well-being were critical to include in the basin report card. For each category, several indicators were determined that could be used to calculate the status of basin health. Unfortunately, data were not available for all proposed indicators. The indicators with sufficient data were water quality, risks to water quality, water supply and demand, natural land cover, stable forest area, terrestrial connectivity, fire frequency, human nutrition, mining pressure in sensitive ecosystems, and river dolphins. These indicators form the basis of the Colombian Orinoco River Basin Health Report Card.

Figure 1-1 Potential indicators established for the Orinoco basins.

1.3 Chosen Indicators

Eleven indicators were shortlisted to measure the health of the Orinoco Basin. The status of these indicators was evaluated by comparing data to scientifically-derived thresholds or goals. The report card includes multiple indicators and combines them into a score for each of the sub-basins in addition to an overall score for the Orinoco River Basin in Colombia.

Most of the indicators are derived from official information sources such as the Colombian Environmental Information System. However, significant limitations remain to be able to assess all of the indicators identified through stakeholder engagement. Further research and development over the next few years will improve the rigor and value of the report card by including additional key biodiversity indicators and impacts from oil and gas (consistently raised as topic of interest and concern during all workshops) and agro-industry development.

Water Quality Index

The water quality index assesses the status of water quality variables (dissolved oxygen, total suspended solids, chemical oxygen demand, electrical conductivity, and pH) based on data from the Environmental Information System Indicators (IDEAM).

Risks to Water Quality

The risks to water quality index estimates pressure to water quality due to pollution loads discharged by industry and water use by domestic, livestock, and coffee processing sectors (IDEAM).

Water Supply and Demand

The water supply and demand index is the balance between the availability of water in the watershed, environmental flow requirements, and the water demand by different economic sectors (IDEAM).

Natural Land Cover

The natural land cover indicator measures landscape conversion by comparing the area of natural to non-natural (developed) in the basin, based on satellite imagery for 2012. Loss of natural land cover impacts biodiversity in the basin (PEMO).

Stable Forest Area

This indicator measures the amount of forest that has remained stable in the Amazonian transition sub-basins for the period 1990—2014, where forests are the main or dominant ecosystem. Forest area was calculated using satellite imagery (IDEAM 2015, Forest monitoring system).

Terrestrial Connectivity

Wildlife depends on connectivity between different ecosystems and habitats. The Landscape Shape Index (from University of Massachusetts, Amherst) was used as a measure of fragmentation of terrestrial habitats within each basin.

Fire Frequency

Fire has been shaping parts of the savanna ecosystems for thousands of years. The fire indicator examines the average frequency of fires over the last three years (2013-2015) in each sub-basin compared to historical fire trends.

Ecosystem Services

The Ecosystem Services Regulation Indicator is based on the average of Climate Regulation by Carbon Storage, (PEMO 2013), Hydrologic Regulation Index that measures the amount of moisture that can be retained in basins (IDEAM 2015), and the Soil Erosion Susceptibility Zoning that shows the different erosion rates based on land assessment methods (IDEAM 2015).

Human Nutrition

The human nutrition indicator assesses the percentage of children aged 0-4 with a healthy body weight. This indicator is a proxy for the capacity to provide enough food for people in the basin. Information on human weight was available from the National "Survey of the Nutritional Status in Colombia" conducted in 2010.

Mining in Sensitive Ecosystems

This indicator examines the presence of mining concessions within sensitive ecosystems including: páramos, montane forest, riparian forest, wetlands, and flooded savannas.

River Dolphins

River dolphins are listed as a vulnerable species in Colombia and are an important indicator species of river health where they are present. Data from the Omacha Foundation includes estimates of abundance and habitat use patterns in the Meta, Orinoco, Bita, Arauca, Guaviare, and Inírida rivers.

1.4 Reporting Regions

The National Water Policy in Colombia adopts a hierarchical hydrological system, defined by four scales: *macrobasins*, *zones*, *sub-zones and micro-basins and aquifers*. For the purpose of this report card, however, the terminology adopted by the National Water Policy was adjusted for ease of interpretation and reporting as follows:

- macrobasin =“river basin” (i.e. Orinoco River basin)
- zones = “sub-basins” (e.g. Arauca River sub-basin)

Sub-zones are the hydrological scale designated by the National Water Policy for planning and management. The report card did not report to this fine scale, instead combined data from these sub-zones per sub-basin. The larger sub-basins of the Meta and Guaviare Rivers were divided to assist in reporting the varied geography, habitats and environmental conditions that exist along these sub-basins that stretch from the Andes in the east to the Orinoco River in the west.

Based on the above terminology, the Orinoco River basin in Colombia was divided into ten sub-basins, each receiving individual report card scores (Figure 1-2). These sub-basins are:

- Aruaca River (including headwaters of Cinaruco and Capanaparo rivers)
- Atabapo River
- Bita River
- Guaviare River (divided into Upper, Middle, and Lower)
- Inirida River
- Mataven River
- Meta River (divided into Upper, Middle, Lower, Casanare, and Manacacias)
- Tomo River
- Tuparro River
- Vichada River

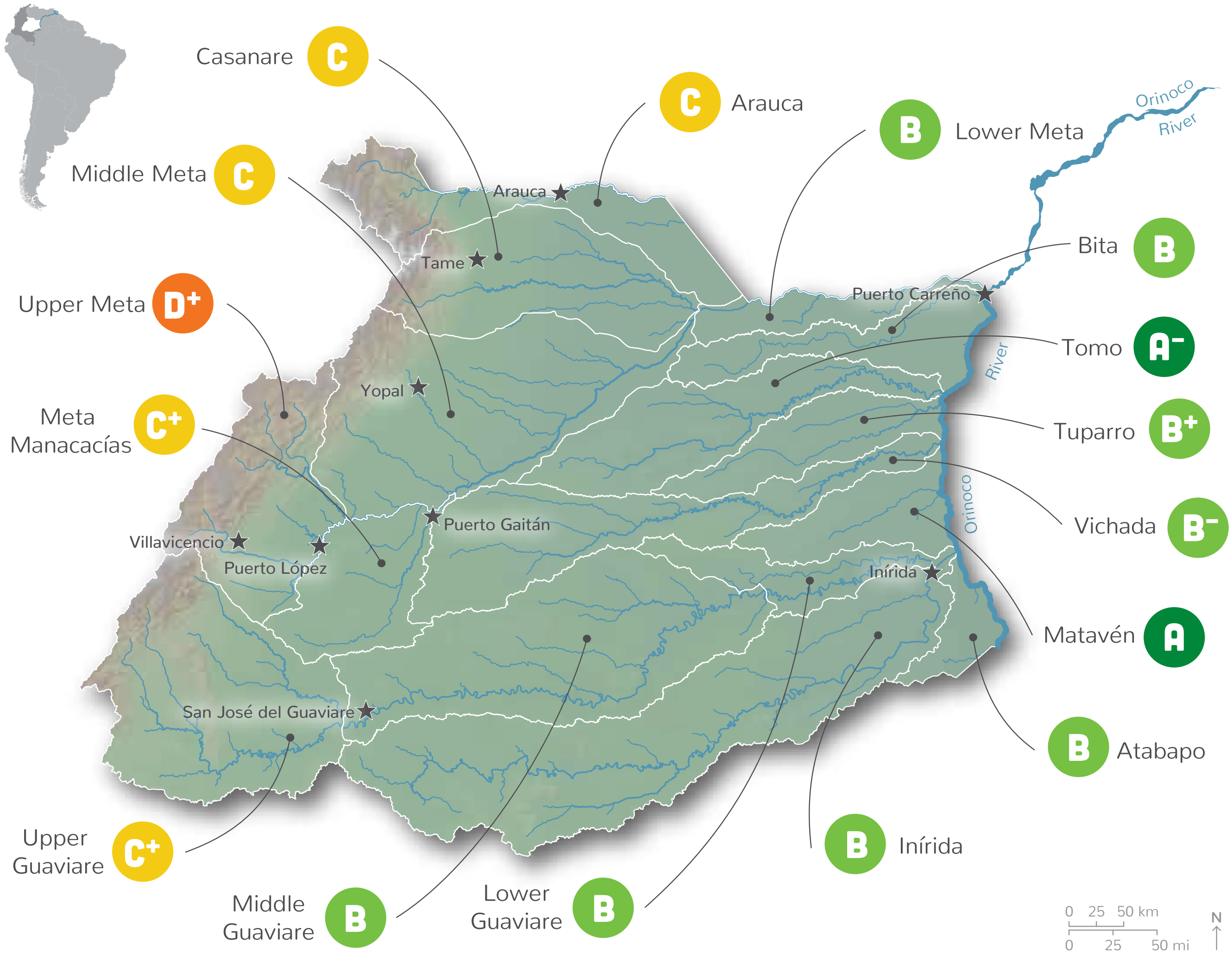


Figure 1-2. The Orinoco River and its ten basins.

1.5 Calculating Scores and Grades

In Colombia grades are displayed in a 0 - 5 scale. Whereas in this English version of the methodology report, grades range from A-F and are assigned + or - (e.g. B+ or B-) if attainment scores are within 5% of the cutoff between grades. For example, 75% would equate to B+; whereas 65% would equate to a B- (Figure 1-3).

The process of calculating report card scores required collation and synthesis of multiple datasets and conversion of raw data into percentage attainment of pre-defined goals or thresholds. This resulted in percentage attainment scores for each indicator in each river basin. Attainment scores for each indicator were averaged by value, and then averaged across values in each sub-basin (as per Table 1-1) to arrive at one attainment score for each sub-basin. Report card grades were assigned based on this average score for each river region.

A 80–100% **Excellent**

All indicators meet objectives. Indicators in these locations tend to be very good, most often leading to preferred conditions.

B 60–80% **Good**

Most indicators meet objectives. Indicators in these locations tend to be good, often leading to acceptable conditions.

C 40–60% **Moderate**

There is a mix of some indicators that meet objectives, and others that do not. Indicators in these locations tend to be fair, leading to sufficient conditions.

D 20–40% **Poor**

Some or few indicators meet objectives. Indicators in these locations tend to be poor, often leading to degraded conditions.

F 0–20% **Failing**

Very few or no indicators meet objectives. Indicators in these locations tend to be very poor, most often leading to unacceptable conditions.

Figure 1-3. Report card indicator attainment scores and corresponding report card grades.

Table 1-1. Orinoco River Report Card indicators, values and scoring system.

Indicators	Values	Scoring System	Grading System
Water quality (0-100%)	Water (0-100%)	0-100%	F-A
Risk to water quality (0-100%)			
Water supply and demand (0-100%)			
Natural land cover (0-100%)	Ecosystems and Landscapes (0-100%)		
Stable forest area (0-100%)			
Fire frequency (0-100%)			
Terrestrial connectivity (0-100%)			
Ecosystem services (0-100%)			
Human nutrition (0-100%)	People and Culture (0-100%)		
Mining in sensitive ecosystems (0-100%)	Management and Governance (0-100%)		
Dolphin abundance (0-100%)	Biodiversity (0-100%)		

2 Water

2.1 Water Quality Index

Overview

Protecting the quality of water in the Orinoco River benefits a multitude of uses such as drinking water, food resources, fish habitat, recreation and irrigation.

Data source

Data on water quality was sourced from IDEAM's Environmental Information System for the year 2013, except for the Bita River which had more recent data (2015) available in the Basin Management Plan (Corporinoquia, 2015). The water quality index is based on six variables collected from stations throughout the basin on a quarterly basis (Basic Network Monitoring Program). It is based on the superficial water quality and is calculated on an annual basis. No data was available for the Arauca, Atabapo, Mataven, Tomo, or Tuparro sub-basins.

The monitoring stations are strategically located depending on the productive activities that exert most pressure on water resources in each region. The variables are: dissolved oxygen, total suspended solids, chemical oxygen demand, electrical conductivity, and pH. The sixth variable is the ratio of total nitrogen to total phosphorus.

The number of stations and station names available to assess water quality in each basin were as follows: Bita x 7 (Stations 1-7); Guaviare x 4 (32077080, 32097010, 32207010, 32077070)

The index varies between 0 and 1, where 0 is poorer water quality conditions and 1 is higher water quality conditions (IDEAM, 2011) (Table 2-1).

Calculation method and results

The water quality index for all stations in each sub-basin were averaged as per the following equation.

$$WQ_{sb} = \frac{\sum_{i=0}^{n} WQ}{n}$$

where
WQ_{sb} = water quality index by sub-basin
WQ = water quality by station
n = number of stations in each sub-basin

This average value for the water quality index was then converted to the standardized 0-100% reporting scale used for all indicators in the report card as per Table 2-1. Final results are displayed in Figure 2-1 and in Table 2-2.

Table 2-1. The conversions between IDEAM water quality index score and report card score.

IDEAM		Report Card		Conversion
Condition	**Score**	**Report card**	**Score (%)**	
Good	0.91-1.00	***Very good***	80-100	y = 2.22x - 122.22
Acceptable	0.71-0.90	***Good***	60-80	y = x - 11
Regular	0.51-0.70	***Fair***	40-60	y = x - 11
Bad	0.26-0.50	***Poor***	20-40	y = 0.8x - 0.8
Very bad	0.00-0.25	***Very poor***	0-20	y = 0.7692x

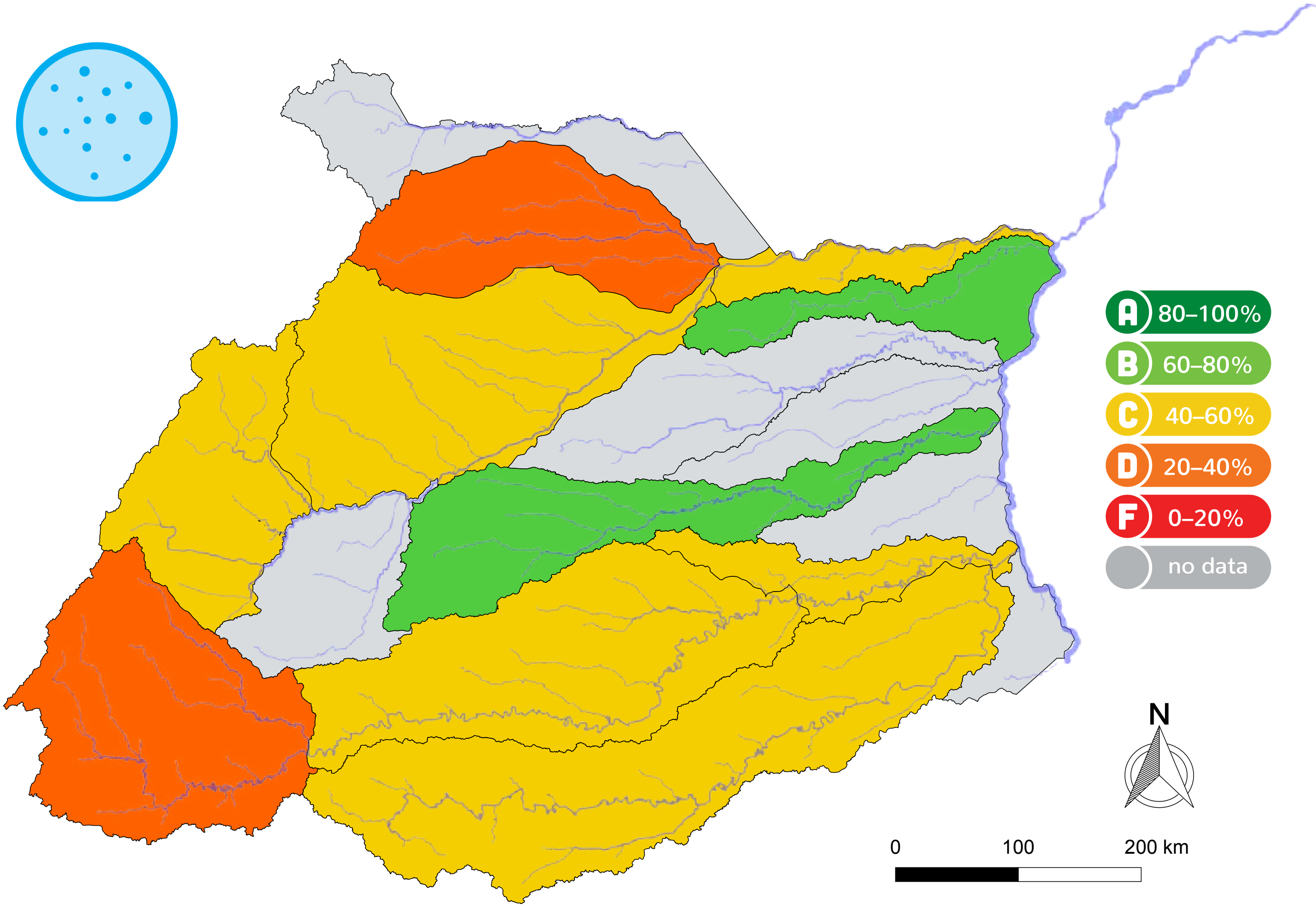


Figure 2-1. Map showing the water quality index scores.

Table 2-2. Final water quality scores.

River basin	Score (0-100)
Arauca	-
Atabapo	-
Bita	64
Guaviare	
Upper	35
Middle	52
Lower	51
Inirida	57
Mataven	-
Meta	
Upper	52
Middle	46
Lower	47
Casanare	37
Manacacias	-
Tomo	-
Tuparro	-
Vichada	63

2.2 Risk to water quality

Overview

The potential change in water quality index, or risk to water quality, analyzes how much pressure pollution discharges have on river waters. The analysis includes measures of organic matter, nutrients and suspended solids, as well as other conditions affecting water quality.

Data source

Data on risk to water quality was sourced from IDEAM's Potential Alteration of Water Quality Index (IACAL) in the National Water Assessment 2014 (IDEAM, 2015). Pollution pressures on water systems in the Orinoco are analyzed by estimating specific pollution loads discharged by industrial, domestic, livestock and coffee processing sectors. Estimates are made for Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), total suspended solids (TSS), total nitrogen (TN), and total phosphorus (TP). The calculation is the sum of the pollution loads by economic sector minus the reduction of pollutants through industrial and domestic water-treatment plants. The index is calculated every four years and takes into account yearly variations in precipitation producing wet and dry scenarios. This analysis is completed using the dry scenario data to reflect worst case scenarios of risk.

For each hydrographic sub-zones (Figure 2-2), IDEAM calculates IACAL based on the following sectors:

- Domestic = BOD from population in ton/year
- Industrial = BOD from industrial activities in ton/year
- Coffee = BOD from the coffee process in ton/year
- Dumping of slaughterhouses = BOD from the slaughtering at municipality level in ton/year
- Other activities (including mining) = COD, BOD, TSS, TN and TP in ton/year at municipality level in ton/year.

IACAL is categorized into five classes (Table 2-3), with lower values indicating lower risk to water quality.

Table 2-3. IDEAM scoring system for risk to water quality.

Category (Amount of risk)	Value	Color
Low	1	
Moderate	2	
Medium High	3	
High	4	
Very high	5	

Figure 2-2. Map of potential risk to water quality - dry scenario.

Calculation method and results

IACAL for all sub-zones within a sub-basin were averaged as per the following equation.

$$IACAL_{sb} = \frac{\sum_{i=0}^{n} IACAL_{hsz}}{n}$$

where

$IACAL_{sb}$ = potential alteration of water quality index by sub-basin

$IACAL_{hsz}$ = potential alteration of water quality index by hydrographic sub-zone

n = *number of* hydrographic sub-zones *in* each *sub-basin*

This average value for IACAL was then converted to the standardized 0-100% reporting scale used for all indicators in the report card as per Table 2-1. Final results are displayed in Figure 2-1 and in Table 2-2.

Table 2-4. The conversions between IDEAM potential change in water quality score and report card score.

Condition	IDEAM Score	Report card score %	Conversion
Very good	0-1.0	80-100	y = -20x + 100
Good	1.0-2.0	60-80	
Fair	2.0-3.0	40-60	
Poor	3.0-4.0	20-40	
Very poor	4.0-5.0	0-20	

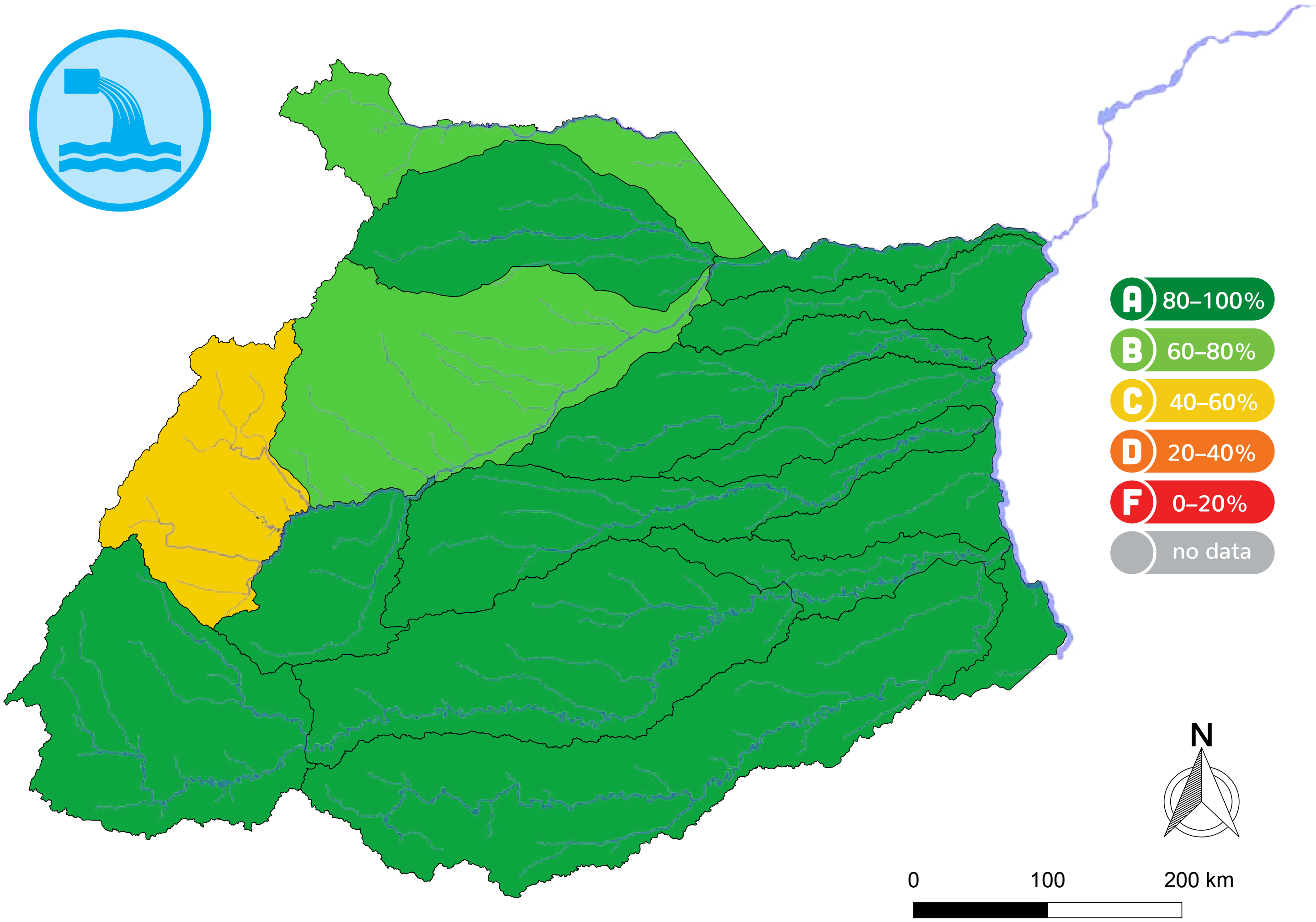


Figure 2-3. Map showing the risk to water quality scores.

Table 2-5. Final risk to water quality index scores.

River basin	Score (0-100)
Arauca	69
Atabapo	80
Bita	100
Guaviare	
Upper	82
Middle	97
Lower	90
Inirida	87
Mataven	100
Meta	
Upper	59
Middle	76
Lower	80
Casanare	84
Manacacias	88
Tomo	100
Tuparro	80
Vichada	100

2.3 *Water supply and demand*

Overview

The water supply and demand indicator is a measure of water availability in the watershed, including that required for environmental flow, compared to water demand by different economic sectors.

Data source

Data was sourced from IDEAM's National Water Assessment (2015). The indicator is based on the Water Use Index (IUA) that compares the amount of water used by different sectors in a given period of time relative to the surface water supply available for the same temporal and spatial units (IDEAM, 2015). Values are reported for both wet and dry scenarios. The considered sectors are: agriculture, industry, services, energy, aquaculture and unconsumed water.

IUA is categorized into five classes (Table 2-6), with lower values indicating lower risk to water quality.

Table 2-6. IDEAM scoring system for IUA

Category (Amount of demand)	Value	Color
Very high	>50	
High	20.01-50	
Moderate	10.01-20	
Low	1-10	
Very low	<1	

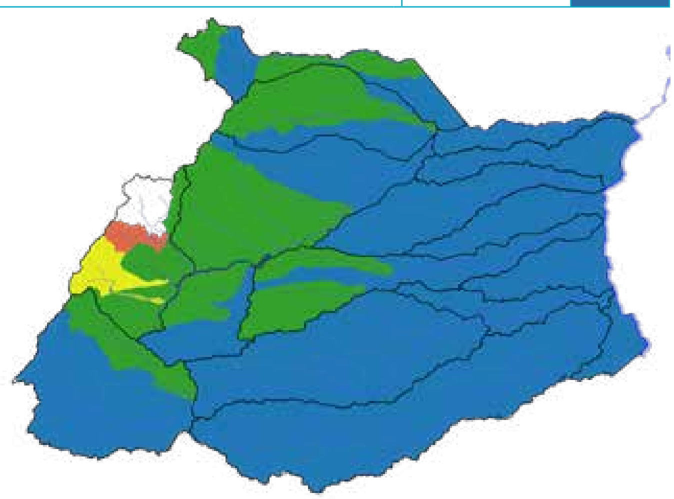


Figure 2-4. *Water supply and demand - dry scenario.*

Calculation method and results

This analysis is completed using the dry scenario data to reflect worst case scenarios of risk. IUA for all sub-

$$IUA_{sb} = \frac{\sum_{i=0}^{n} IUA_{hsz}}{n}$$

where
$IAU_{sb} =$ *water use index by sub-basin*
$IAU_{hsz} =$ *water use index by hydrographic sub-zone by sub-basin*
$n =$ *number of hydrographic sub-zones in each sub-basin*

zones within a sub-basin were averaged as per the following equation.

This average value for IUA was then converted to the standardized 0-100% reporting scale used for all indicators in the report card as per Table 2-5. Final results are displayed in Figure 2-5 and in Table 2-7.

Table 2-5. The conversions between IDEAM's scoring system and the report card score.

Condition	IDEAM's Score	Report card score (%)	Conversion
Very good	0 - <1.0	80-100	y = -20x + 100
Good	1.0 - 10.0	60-80	y = -2.222x + 82.222
Fair	10.01 - 20.0	40-60	y = -2x + 80
Poor	20.01 - 50.0	20-40	y = -0.667x + 53.333
Very poor	50.01 - >100	0-20	y = -0.4x + 40

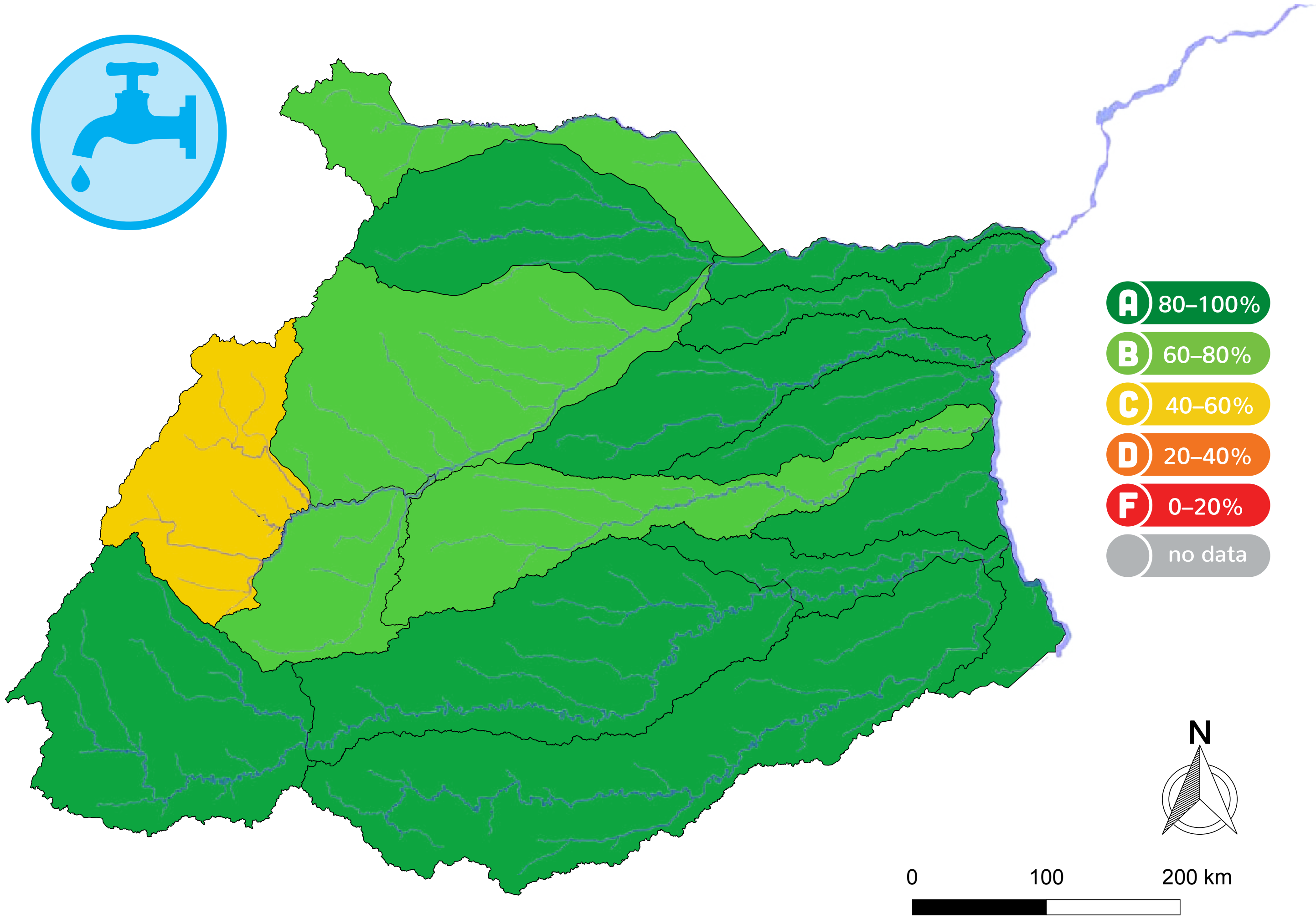


Figure 2-5. Map showing the risk to water quality scores by sub-basin.

Table 2-7. Final water supply and demand scores.

River basin	Score (0-100)
Arauca	78
Atabapo	100
Bita	96
Guaviare	
Upper	89
Middle	99
Lower	100
Inirida	99
Mataven	100
Meta	
Upper	45
Middle	77
Lower	95
Casanare	81
Manacacias	79
Tomo	96
Tuparro	99
Vichada	79

3 Ecosystems and Landscapes

3.1 Natural land cover

Overview

The natural land cover indicator measures the change from natural areas to developed or non-natural areas. Loss of natural land cover can impact biodiversity and important species in the region.

Data source

Land cover data was sourced from Landsat imagery and classified through the National Environment System led by IDEAM, for the period 2010-2012 (published in 2015 - Figure 3-1). The periodicity of this information is every 5 years.

Calculation method and results

Natural land cover was defined as per the method used by the Humboldt Institute, 4D and Ingeag to develop Phase I and II of the Orinoco Macrobasin Management Plan (PEMO) where land cover was reclassified as natural and non-natural classes (IAVH, *et al.* 2013).

Natural land cover was calculated as the area of natural lands as a percentage of total area for each sub-basin as per the following equation. This average value for IUA was then converted to the standardized 0-100% reporting scale used for all indicators in the report card as per Table 2-5. Final results are displayed in Figure 2-5 and in Table 2-7.

$$NLC_{\%} = \frac{NLC_{sb}}{A_{sb}} \times 100$$

where
$NLC_{\%}$ = percentage of natural land cover
NLC_{sb} = natural land cover area by sub-basin
A_{sb} = total area of the sub-basin

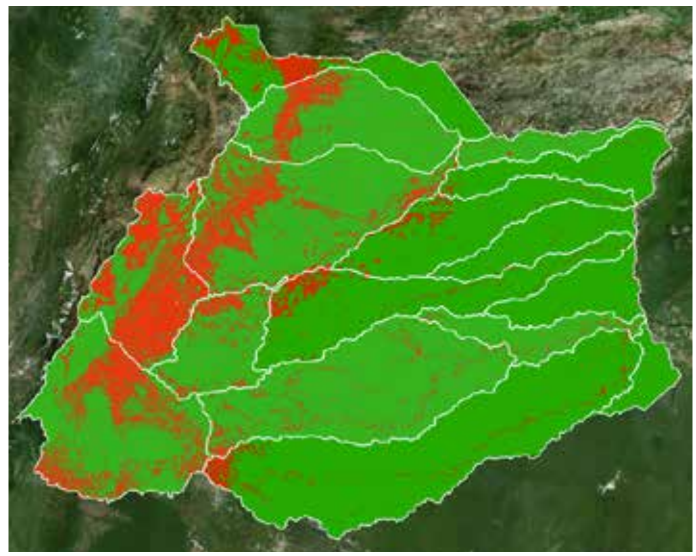


Figure 3-1. Natural land cover map. Green represents natural land cover and red represents non-natural area.

The following classification scheme was used to categorize natural vs. non-natural lands:

Natural

- Forest
- Shrub-land
- Herbaceous lands
- Water bodies
- Wetlands

Non-natural

- Pastures
- Forest plantations
- Crops
- Urban and other impervious categories

Final results are displayed in Figure 3-2 and in Table 3-1.

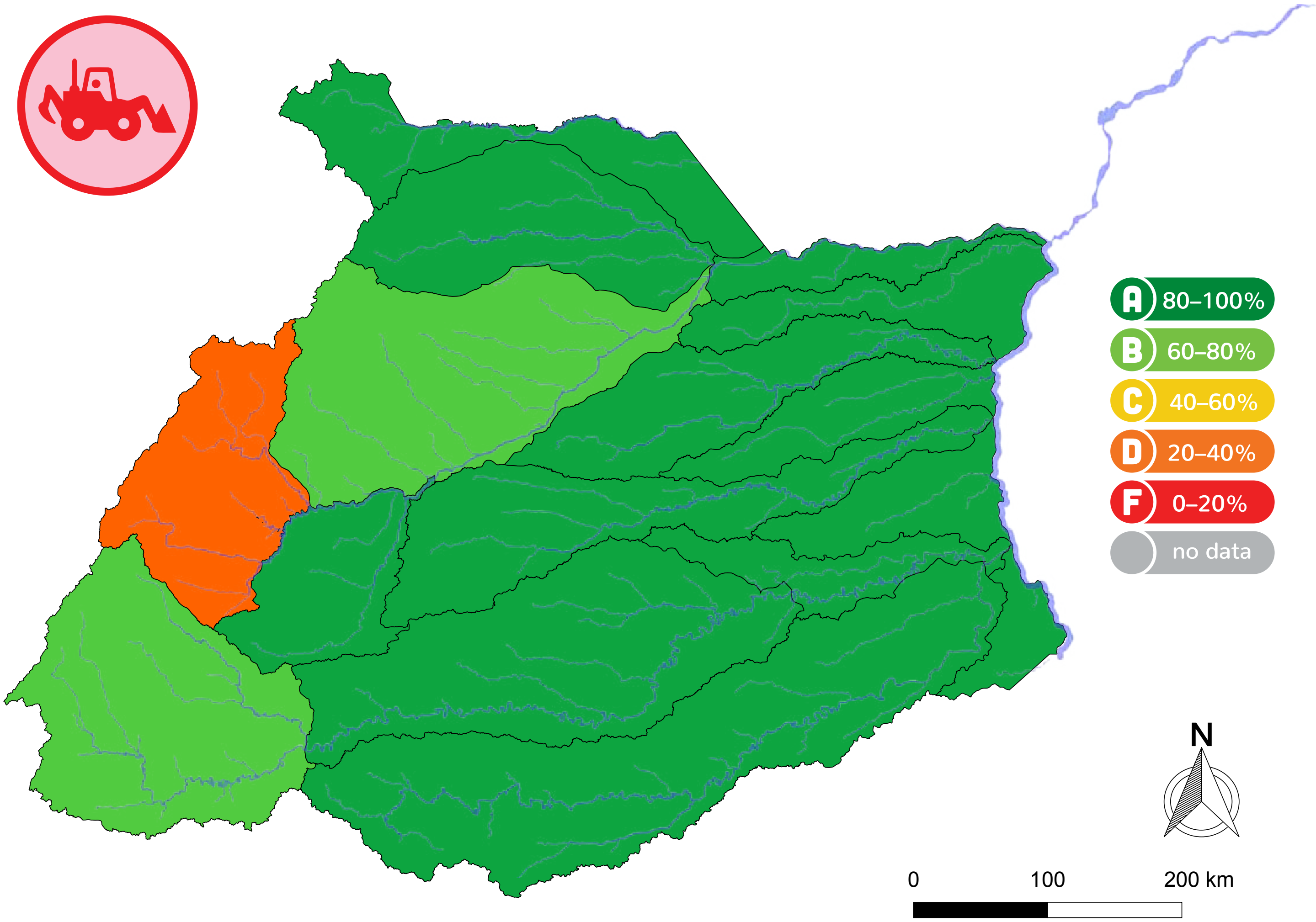


Figure 3-2. Map showing the natural land cover scores.

Table 3-1. Final natural land cover scores.

River basin	Score (0-100)
Arauca	81
Atabapo	100
Bita	98
Guaviare	
Upper	70
Middle	96
Lower	98
Inirida	97
Mataven	100
Meta	
Upper	38
Middle	75
Lower	96
Casanare	85
Manacacias	84
Tomo	93
Tuparro	100
Vichada	93

3.2 Stable forest area

Overview

Forests are important resources in the Orinoco River Basin. They provide homes for not only wildlife, but also for humans. People rely on forests for many services, such as water, food, building materials, and clothing. Threatened animals also rely on forests for their food and shelter. Forests around the Orinoco are under threat from deforestation. Deforestation occurs not only from logging for timber goods, but also from fires, agriculture, ranching, and development. Deforestation impacts plants and animals as well as humans.

This indicator measures the amount of forest that has remained stable in the Amazonian transition sub-basins for the period from 1990–2014, where forests are the main or dominant ecosystem.

Data source

Forest area was sourced from IDEAM's Forest Monitoring System (IDEAM, 2015). The periodicity of this information is annual. For those sub-basins where savannas are the dominant ecosystem, this indicador was not applied

Calculation method and results

This indicator was only calculated for sub-basins in the Amazonian transition zone where forests are the natural vegetation type: Atabapo, Inirida, Guaviare, and Mataven sub-basins.

The amount of forested area in 2014 as a percentage of forested area in 1990 (Figure 3-3) was used to calculate stable forest area as per the below equation:

$$SFA_{sb} = \frac{FA_{2014}}{FA_{1990}} \times 100$$

where
SFA_{sb} = *percentage stable forest area by sub-basin*
FA_{2014} = *forest area in 2014*
FA_{1990} = *forest area in 1990*

Final results are displayed in Figure 3-4 and in Table 3-2.

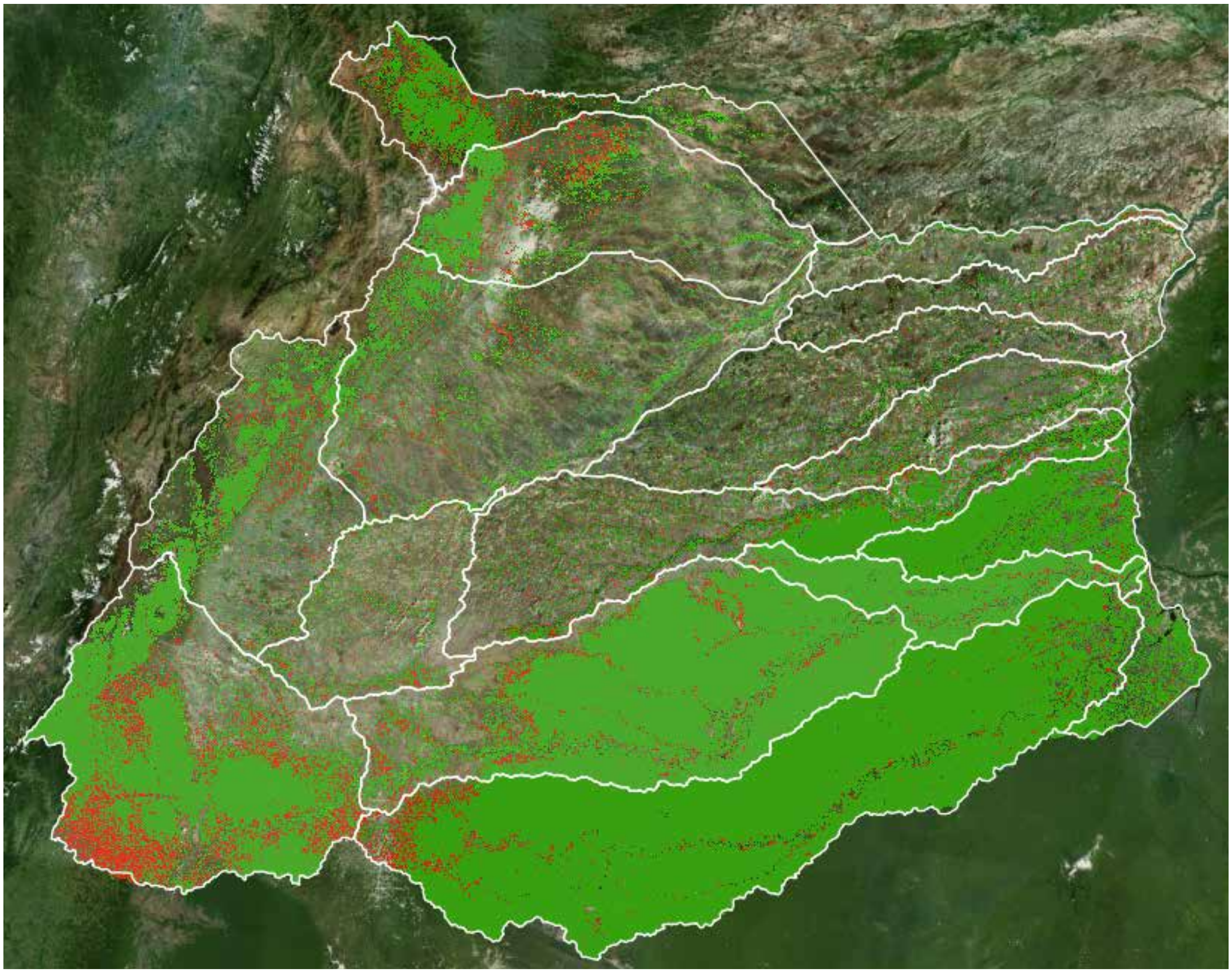


Figure 3-3. Map showing areas of stable forest (green)and areas of deforestation (red) within the Orinoco River basin.

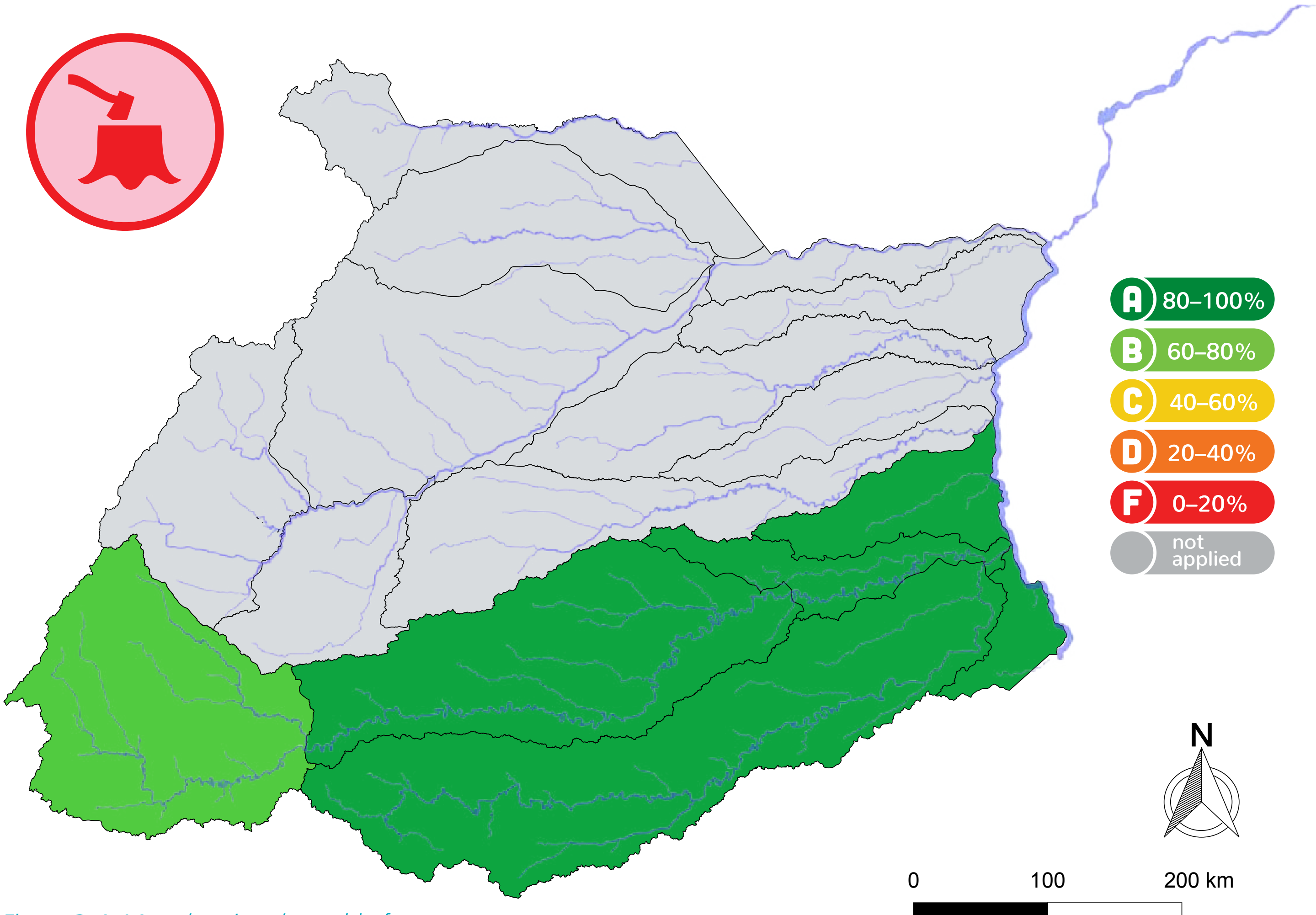


Figure 3-4. Map showing the stable forest area scores.

Table 3-2. Final stable forest area scores.

River basin	Score (0-100)
Arauca	Not applicable
Atabapo	97
Bita	Not applicable
Guaviare	
Upper	76
Middle	95
Lower	97
Inirida	97
Mataven	98
Meta	
Upper	Not applicable
Middle	Not applicable
Lower	Not applicable
Casanare	Not applicable
Manacacias	Not applicable
Tomo	Not applicable
Tuparro	Not applicable
Vichada	Not applicable

3.3 Terrestrial Connectivity

Overview

Wildlife depends on connectivity between different ecosystems and habitats. Connectivity between habitats allows animals to migrate between patches, which is especially important in times of disturbance. The Landscape Shape Index (from University of Massachusetts, Amherst) was used as a measure of fragmentation of terrestrial habitats within each sub-basin (http://goo.gl/yosRFC). The Landscape Shape Index (LSI), measures the perimeter-to-area ratio of a landscape classification.

Data source

Data was sourced from the 2012 Land Cover Map (IDEAM 2015). The periodicity of the information is every 5 years.

Calculation method

For the purposes of determining terrestrial connectivity for this report card, the perimeter of all natural areas/ patches within each sub-basin was calculated as a proportion of the total sub-basin area. Hence a higher LSI, indicates greater geometric complexity of the landscape; which can be interpreted as higher disaggregation or dispersal of natural areas.

A 100 m pixel size raster layer of natural land cover (sourced and converted from IDEAM, 2015) was analyzed using FRAGSTATS software (McGarical *et al.*, 2012) and a LSI calculated for each sub-basin using the below equation:

$$LSI = \frac{.25 \sum_{k=1}^{m} e_{ik}}{\sqrt{A}}$$

where
LSI = Landscape Shape Index
e_{ik} = total length (m) of edge in the sub-basin, between natural areas i and k
A = total of sub basin area (m)

Values for LSI were between 0-1 with lower values indicating higher connectivity. To reflect the report card scoring system, the LSI was inversed and normalized between 0 and 100% for the terrestrial connectivity score. Final results are displayed in Figure 3-5 and in Table 3-3.

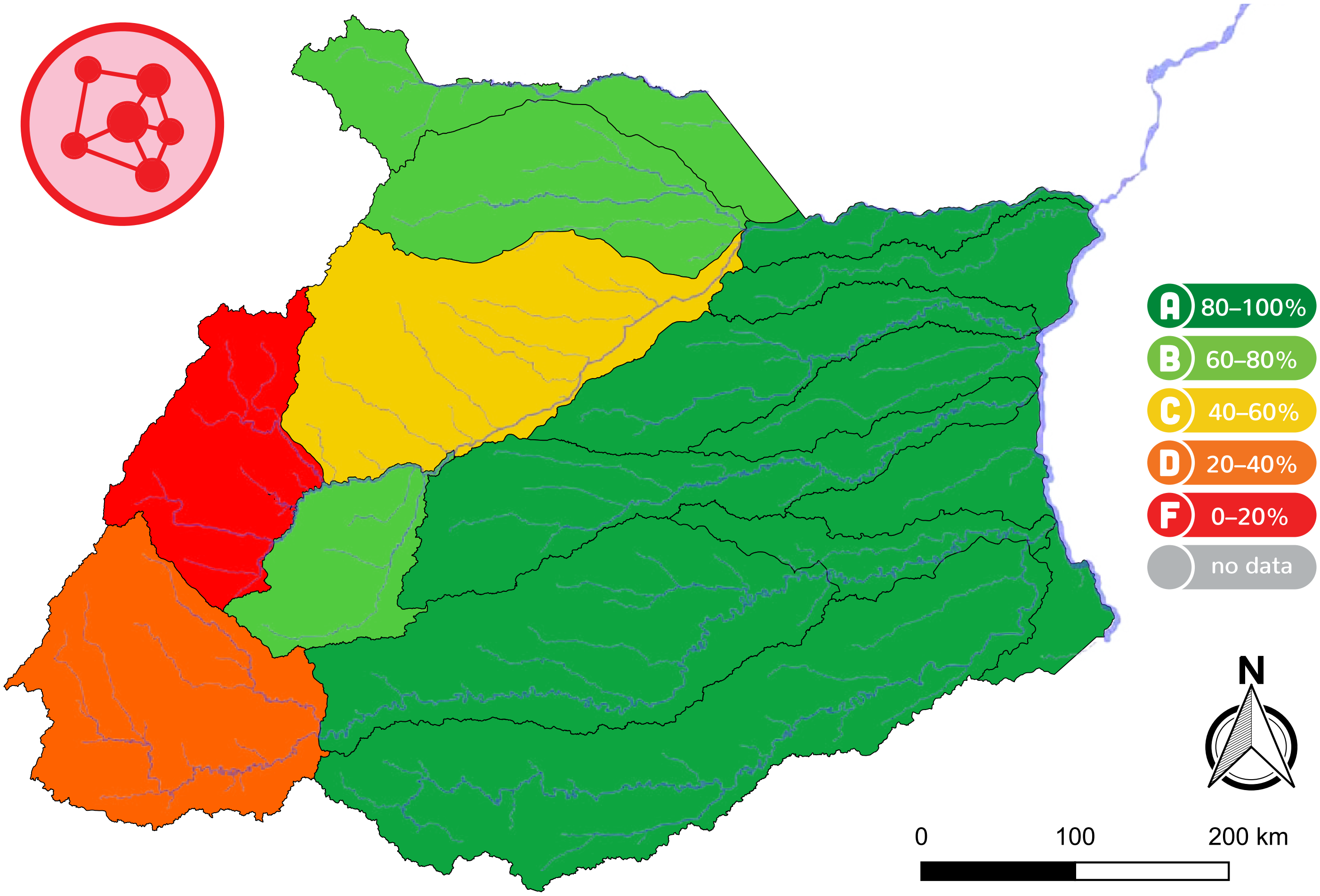


Figure 3-5. Map showing the terrestrial connectivity scores.

Table 3-3. Final terrestrial connectivity scores.

River basin	Score (0-100)
Arauca	72
Atabapo	97
Bita	95
Guaviare	
Upper	23
Middle	85
Lower	94
Inirida	88
Mataven	97
Meta	
Upper	0
Middle	45
Lower	94
Casanare	77
Manacacias	70
Tomo	91
Tuparro	97
Vichada	88

3.4 Fire frequency

Overview

Fire has been shaping parts of the savannah ecosystems within the Orinoco River Basin for thousands of years. Changes to the fire regime however, as a result of increasing development and clearing of land for crops and livestock, can be detrimental to valuable ecosystems such as moriche palms and natural grasslands. The fire frequency indicator examines the average frequency of fires over the last three years (2013-2015) in each sub-basin compared against historical fire trends.

Data source

Two datasets were used: MCD14DL and MCD14ML. The data was provided by the University of Maryland and NASA FIRMS operated by NASA/GSFC/ESDIS with funding provided by NASA/HQ. NASA Near Real-Time and MCD14DL and MCD14ML MODIS Active Fire Detections. Available online at https://earthdata.nasa.gov/active-fire-data#tab-content-6.

Calculation method and results

The fire frequency indicator was assessed only in those basins where savannahs and grasslands are the dominant ecosystem type: Arauca, Bita, Meta, Tomo, Tuparro, and Vichada sub-basins.

Deciles of fire frequencies between 2001-2012 were calculated for each sub-basin (Appendix II) and attributed a report card score between 0-100%. Scores decrease with increased deviation away from the 50th percentile as shown in Table 3-4.

A report card score was determined by comparing the three-year average fire frequency (2013-2015) in each sub-basin against corresponding values in Appendix II to determine which historical decile bin recent fire frequencies fit.

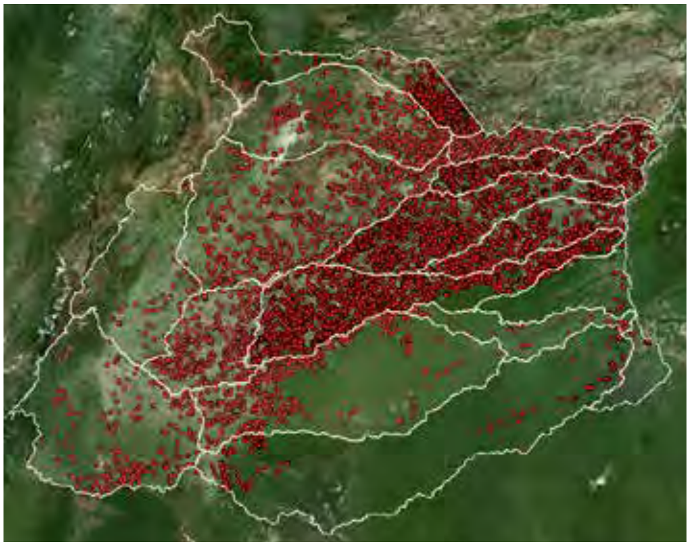


Figure 3-6. Fire frequency map.

Table 3-4. Attribution of report card scores (%) to historical fire frequency deciles.

Decile	Score (%)
100	0
90	20
80	40
70	60
60	80
50	100
40	80
30	60
20	40
10	20
0	0

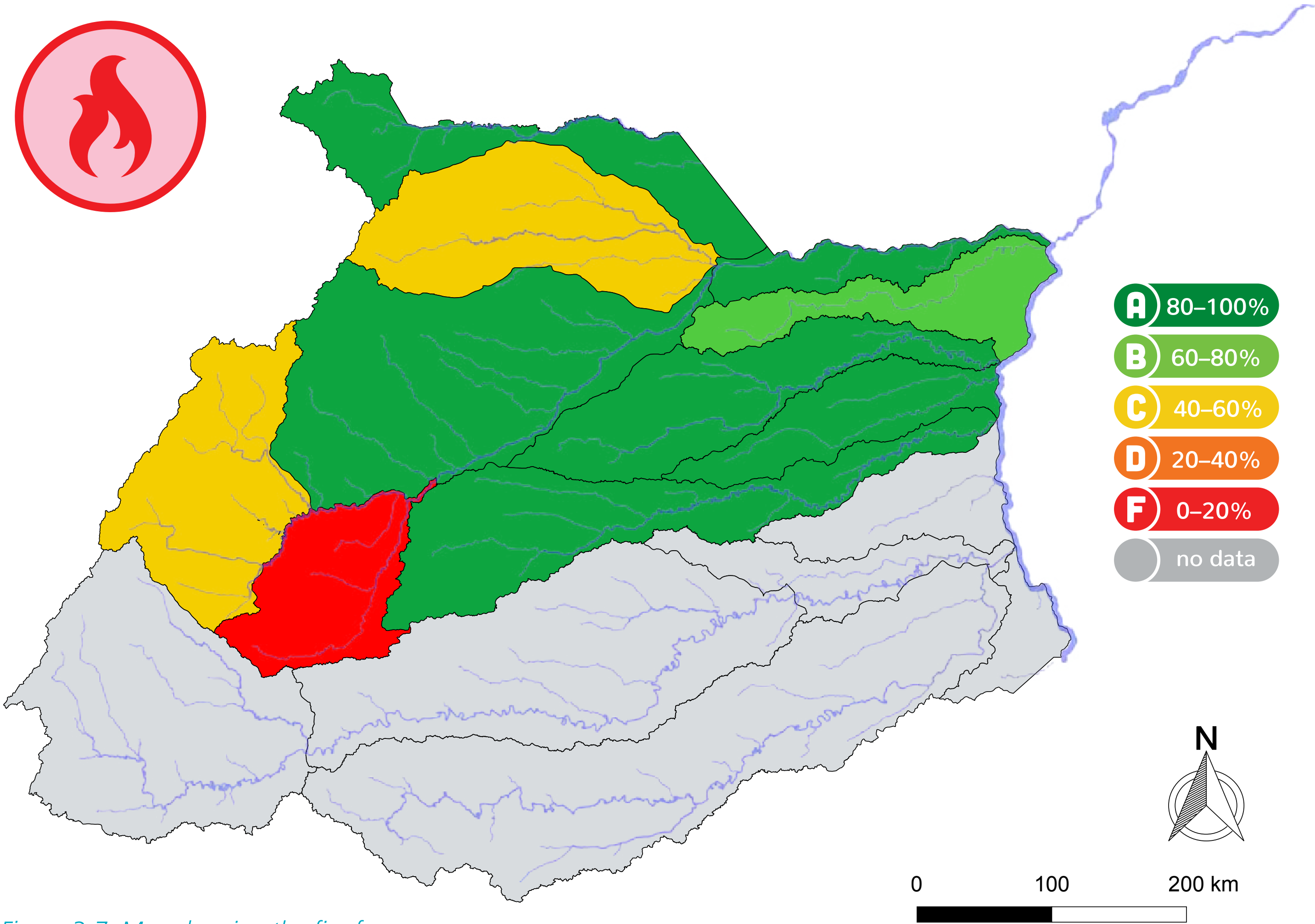


Figure 3-7. Map showing the fire frequency scores.

Table 3-5. Final fire frequency scores.

River basin	Score (0-100)
Arauca	95
Atabapo	Not applicable
Bita	62
Guaviare	
Upper	Not applicable
Middle	Not applicable
Lower	Not applicable
Inirida	Not applicable
Mataven	Not applicable
Meta	
Upper	59
Middle	92
Lower	89
Casanare	50
Manacacias	1
Tomo	95
Tuparro	91
Vichada	96

3.5 Ecosystem services

Overview

Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth (UNEP http://www.unep.org/maweb/documents/document.300.aspx.pdf).

Data source

The Ecosystem Services Regulation Indicator is based on three ecosystem service indicators: 1) Climate Regulation by Carbon Storage (IAVH, *et al.* 2013), 2) Hydrologic Regulation Index that measures the amount of moisture that can be retained in basins (IDEAM 2015), and 3) the Erosion Susceptibility Index that shows the different erosion rates based on land assessment methods (IDEAM 2010).

Calculation method

The Ecosystem Services indicator is the average of results for the Climate Regulation by Carbon Storage, Hydrologic Regulation Index, and the Erosion Susceptibility Index.

Climate Regulation by Carbon storage (CS)

Based upon aboveground biomass maps (IAVH, *et al.* 2013), which classify carbon storage from 1 (less carbon storage) to 4 (more carbon storage), average carbon storage per ecosystem within a sub-basin was calculated as per the following equation:

$$CS_{sb} = \sum_{i=1}^{n} C_{ei} \left(\frac{A_{ei}}{A_{sb}}\right)$$

where

CS_{sb} = carbon storage in each sub-basin

C_{ei} = carbon value (PEMO) for ecosystem i

A_{ei} = area of ecosystem i in sub-basin

A_{sb} = total area of sub-basin

n = number of ecosystems in each sub-basin

Hydrologic Regulation Index

IDEAM categorizes water retainment withing each hydrographic sub-zone between 0-1 (low - high). The HRI of all sub-zones within a sub-basin was averaged and converted to the 0-100% report card scoring system as per the following equation:

$$HRI_{sb} = \frac{\sum_{i=0}^{n} HRI_{hsz}}{n}$$

where

HRI_{sb} = hydrologic regulation index by sub-basin

HRI_{hsz} = hydrologic regulation index by hydrologic sub-zone

n = number of hydrologic sub-zones in sub-basin

Erosion Susceptibility Index (ESI)

IDEAM categorizes soil erosion susceptibility as follows: no erosion = 4; light = 3; moderate = 2; severe = 1; without soil = 0. The ESI of all sub-zones within a sub-basin was averaged and converted to the 0-100% report card scoring system as per the following equation:

$$ESI_{sb} = \sum_{i=1}^{4} ESC_{i} \left(\frac{A_{esci}}{A_{sb}}\right)$$

where

ESI_{sb} = erosion susceptibility index by sub-basin

ESI_{i} = erosion susceptibility category

A_{esci} = area of category i in sub-basin

A_{sb} = total area of sub-basin

Final results are displayed in Figure 3-8 and in Table 35.

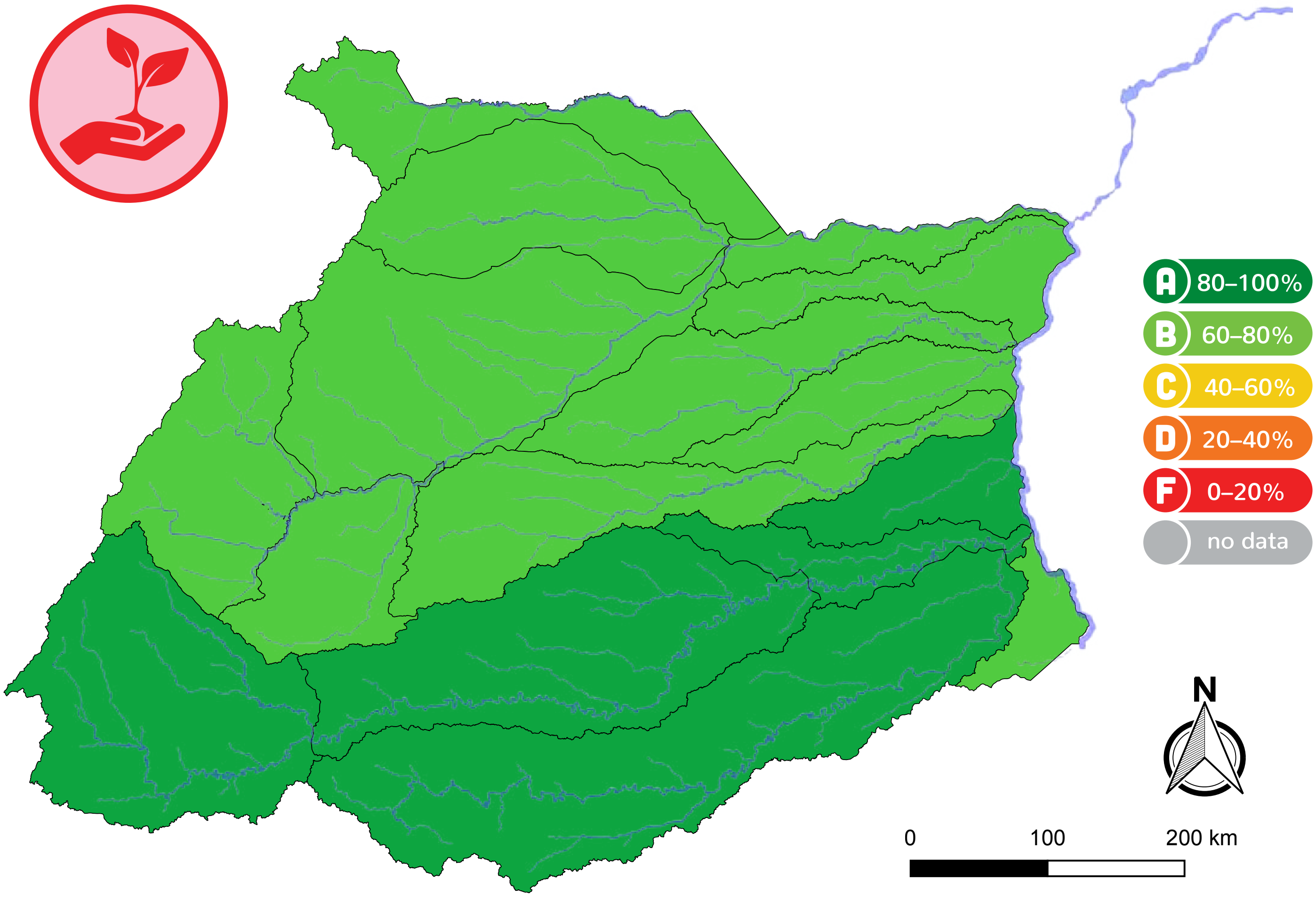


Figure 3-8. Map showing the ecosystem services scores.

Table 3-5. Results for each of ecosystem service indicator assessed and final ecosystem services scores.

River basin	Carbon storage	Hydrologic Regulation Index	Erosion Susceptibility Index	Score (0-100)
Arauca	67	74	66	69
Atabapo	69	87	74	77
Bita	64	82	45	64
Guaviare				
Upper	69	84	87	80
Middle	68	95	95	83
Lower	70	91	88	86
Inirida	70	95	97	87
Mataven	67	96	91	85
Meta				
Upper	65	73	64	67
Middle	63	82	55	67
Lower	64	85	47	65
Casanare	64	83	60	69
Manacacias	71	70	52	64
Tomo	64	79	46	63
Tuparro	65	83	53	67
Vichada	67	81	59	69

4 People and Culture

4.1 Human nutrition

Overview

Adequate food supply in the region is important for human use of and dependence on the river. The human nutrition indicator is based on standard values published by the World Health Organization (WHO) to evaluate nutrition levels in populations from 0 to 4. This indicator is a proxy for the capacity to provide the enough food for people in the basin.

Data source

Information on human weight was available from the National "Survey of the Nutritional Status in Colombia" conducted in 2010 (ENSIN 2010). The Colombian Institute of Familiar Welfare (ICBF in Spanish) sampled infantile populations (between 0 and 4 years old) across the country and compared the distribution of the Colombian population against the reference populations used by WHO (2006).

The categories created for this indicator are:

- Underweight: kids with lower weight than expected depending upon their age (< -2 SD)
- Overweight: kids with higher Body Mass Index (BMI) than expected (> 1 SD and <= 2 SD)
- Obese: kids with much more BMI than expected (> 2 SD)
- Normal: the remaining distribution (>= -2 SD and <= 1 SD)

The human nutrition indicator is calculated every five years by the ICBF.

Calculation method

The human nutrition indicator assesses the percentage of children aged 0-4 with a healthy body weight, as it was considered that this age group was most susceptible to dietary limitations. Data from 2010 were analyzed by department boundary (Figure 4-1). The percent of each department in each sub-basin was then calculated as per Appendix III.

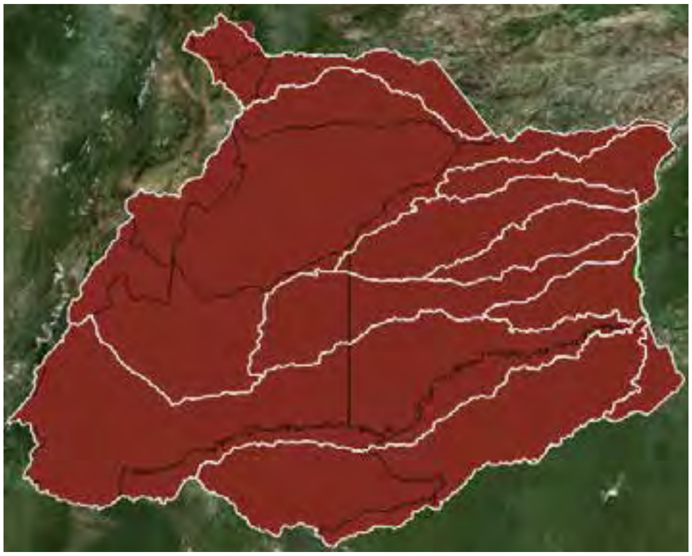


Figure 4-1. Department boundaries (black line) and sub-basin boundaries (white line).

Figure 4-2 shows the relationship and formula used to convert the percentage children (0-4 yrs) within a healthy weight range to a report card score. Note that a minimum of 50% of children were required to be within a healthy weight range to receive a report card score above 0%.

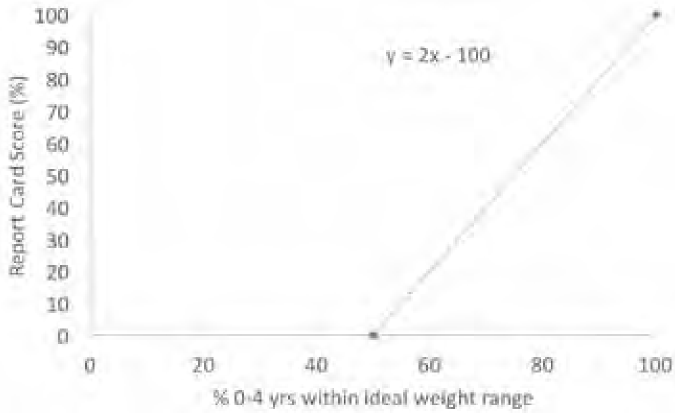


Figure 4-2. Conversion of children within ideal weight range to a report card score.

Final results are displayed in Figure 4-3 and in Table 4-1.

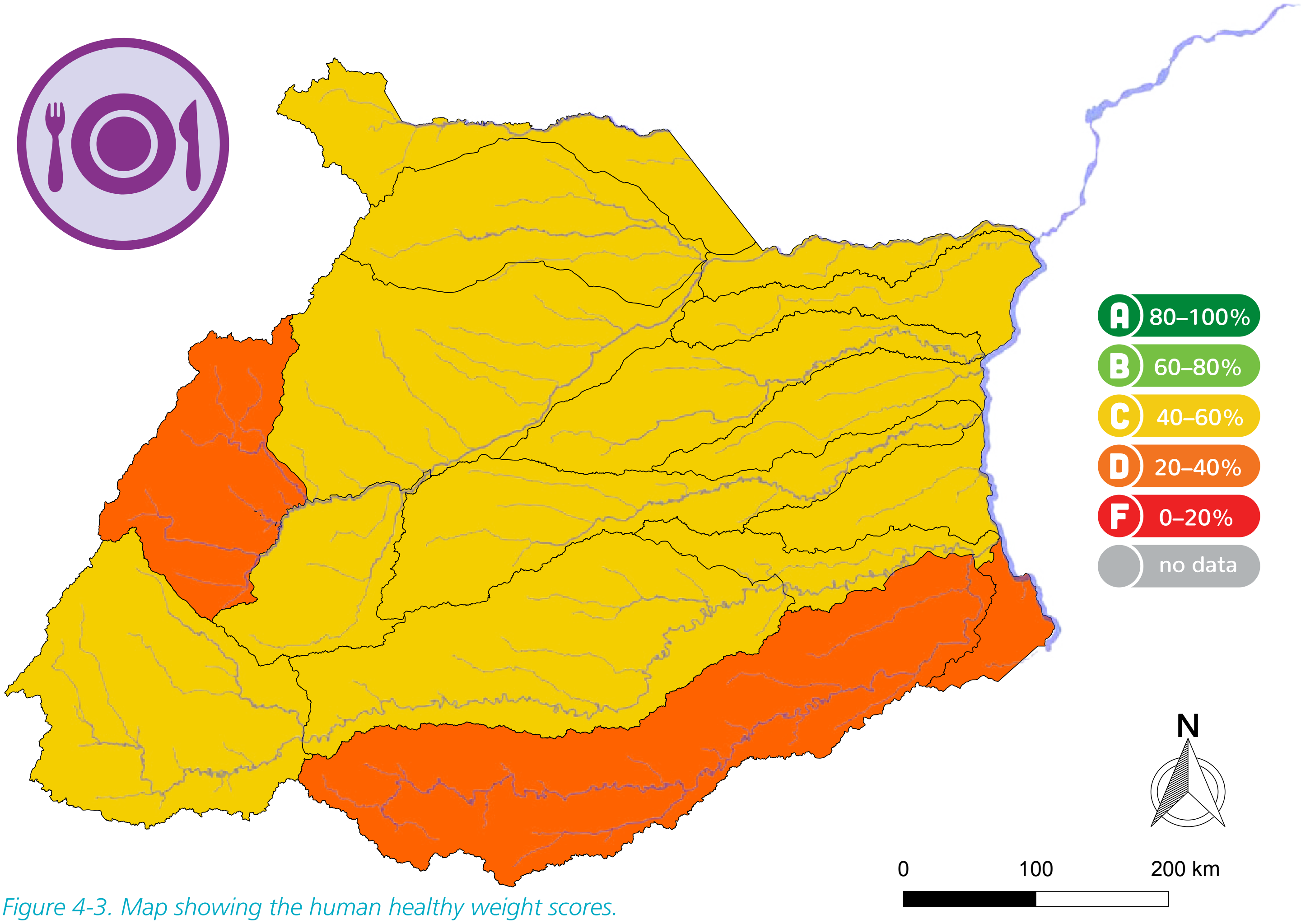


Figure 4-3. Map showing the human healthy weight scores.

Table 4-1. Final human nutrition scores.

River basin	Score (0-100)
Arauca	47
Atabapo	38
Bita	53
Guaviare	
Upper	44
Middle	46
Lower	49
Inirida	31
Mataven	53
Meta	
Upper	39
Middle	51
Lower	53
Casanare	49
Manacacias	46
Tomo	53
Tuparro	53
Vichada	50

5 Management/ Governance

5.1 Mining in sensitive areas

Overview

This indicator examines the presence of mining concessions within sensitive ecosystems including the páramos, montane forest, riparian forest, wetlands, and flooded savannas, rivers and other water bodies.

According with the National Environmental System Law (99 of 1993) of Colombia, paramos zones are subject to special protection for human water consumption and are subject to special protection according to the National Development Plan (1450 of 2011), where agriculture and mining activities are not permitted within these areas.

Additionally, the Environmental Ministry of Colombia through decree 1640 of 2012, specifies the following ecosystems are subject to special management and logging restrictions:

- Paramos
- Wetlands
- Water bodies

Data source

Data on mining concessions was sourced from the National Mining Agency (2015) and the Humboldt Institute for the Orinoco Ecosystem Map (IAVH 2004).

Calculation method

The presence of mining concessions in sensitive ecosystems (riparian forest, paramos, wetlands, water bodies and flooded savannahs) were identified for each sub-basin by cross-referencing mining concession locations and the Orinoco Ecosystem Map (IAVH 2004).

If mining was present in one of the specified ecosystems, it was attributed a score of 0%; if no mining was present in a sensitive ecosystem it was attributed 100%. The average of scores for all sensitive ecosystem types within a sub-basin was the final report card score for "mining in sensitive areas" for that sub-basin. Hence a score of 100% indicates that no mining was present in any of the sensitive ecosystem types, whereas a score of 0% indicates that mining was present in every sensitive ecosystem in that sub-basin, as per the following equation:

$$M_{sei} = \frac{E_{msei}}{E_{sei}} \times 100$$

where

M_{sei} = *percentage of sensitive ecosystems within sub-basin i with mining concessions*

E_{msei} = *number of sensitive ecosystems with mining concessions in sub-basin i*

E_{sei} = *total number of sensitive ecosystems in sub-basin i*

Final results are displayed in Figure 5-1 and in Table 5-1.

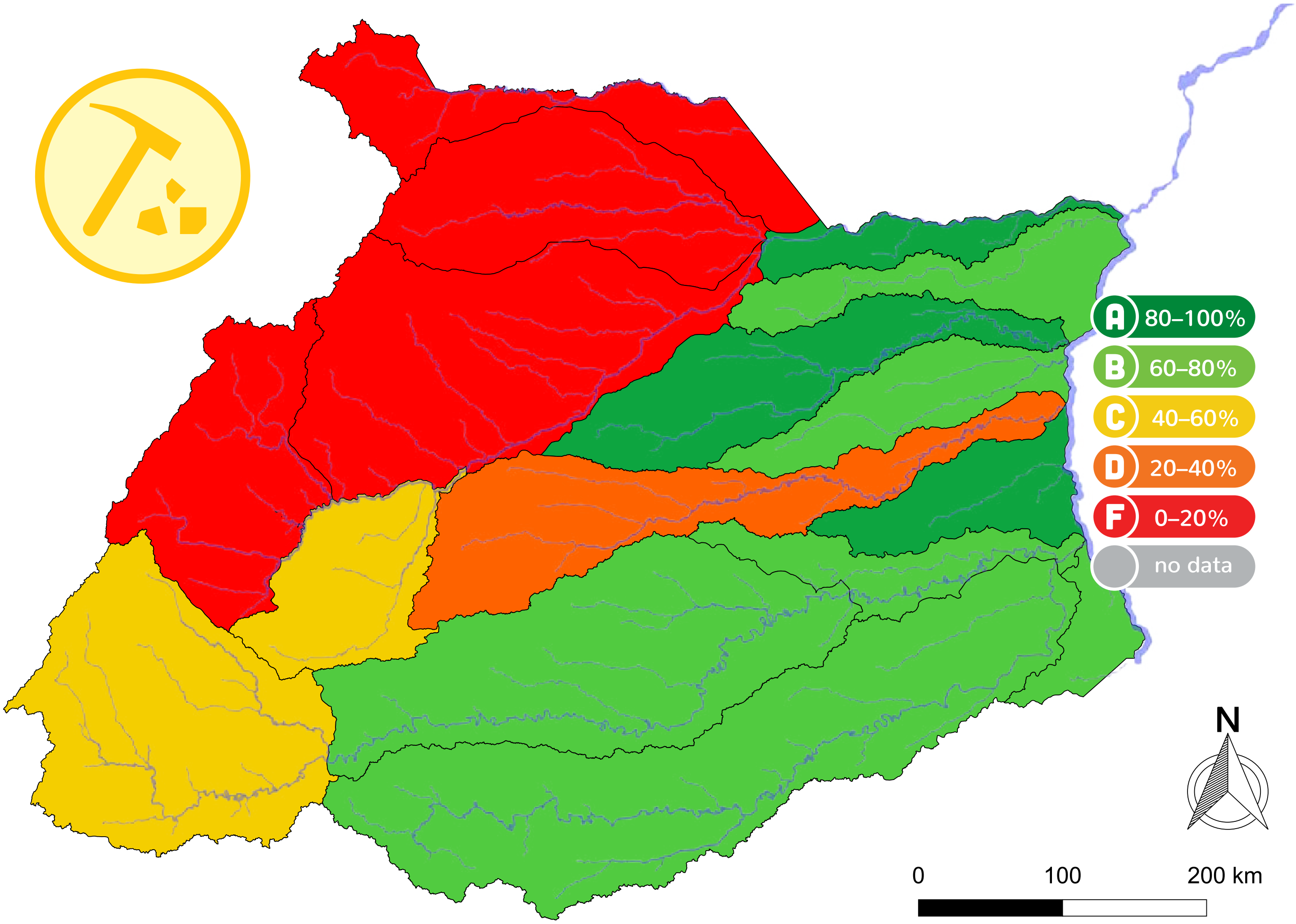


Figure 5-1. Map showing the mining pressure scores.

Table 5-1. Final mining in sensitive areas scores.

River basin	Score (0-100)
Arauca	0
Atabapo	67
Bita	75
Guaviare	
Upper	50
Middle	60
Lower	60
Inirida	67
Mataven	100
Meta	
Upper	17
Middle	17
Lower	100
Casanare	0
Manacacias	40
Tomo	100
Tuparro	75
Vichada	25

6 Biodiversity

6.1 Dolphin abundance

Overview

Dolphins are listed as a vulnerable species in Colombia. They are an important indicator species to describe river health for those rivers where they are present.

Data source

Data and methodology for calculating a report card score were sourced from the Omacha Foundation. The data covers estimates of dolphin abundance and habitat use in the Arauca, Bita, Lower Guaviare, and Middle and Lower Meta sub-basins - reflecting suitable dolphin habitat and available data as at the time of preparing this report card.

Data on dolphin abundance in the Meta and Orinoco River were used to determine dolphin abundance thresholds based on previous works carried out by Omacha Foundation and its partners (Gomez et al 2012).

Calculation method

The stratification of dolphin density was determined for each of the following river habitat types: main river, tributary, channel, island, and confluence (Figure 6-1). The minimum, medium, and maximum densities from historical records were used to set the thresholds for each habitat type in each sub-basin as seen in the table 6-1.

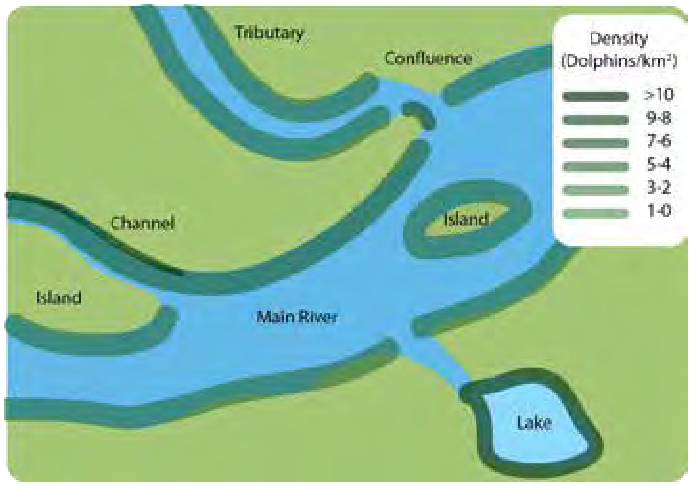


Figure 6-1. Gomez et al 2012

Table 6-1, shows how dolphin abundance, defined by Omacha Foundation, was converted to the report card scoring system for each habitat using a linear regression between minimum (0) and maximum dolphin density in each habitat in each sub basin, and the 0-100 report card score. Habitat values were averaged by sub-basin.

Final results are displayed in Figure 6-2 and in Table 6-2.

Table 6-1. Dolphin abundance by habitat and report card conversion equation.

Habitat	Dolphin Density per km²				Report Card Conversion
	Meta (Medio & Bajo)	Bita	Arauca	Guaviare Bajo	
Main River	0.46	***0.56***	0.26	0.27	y = 87.719x
Tributary	0.72		ND	0.49	y = 133.33x
Channel	2.8		ND	ND	
Island	0.16			ND	y = 76.923x + 2E-14
Confluence	1.52	***7.0***	8.3	6.3	y = 10.101x

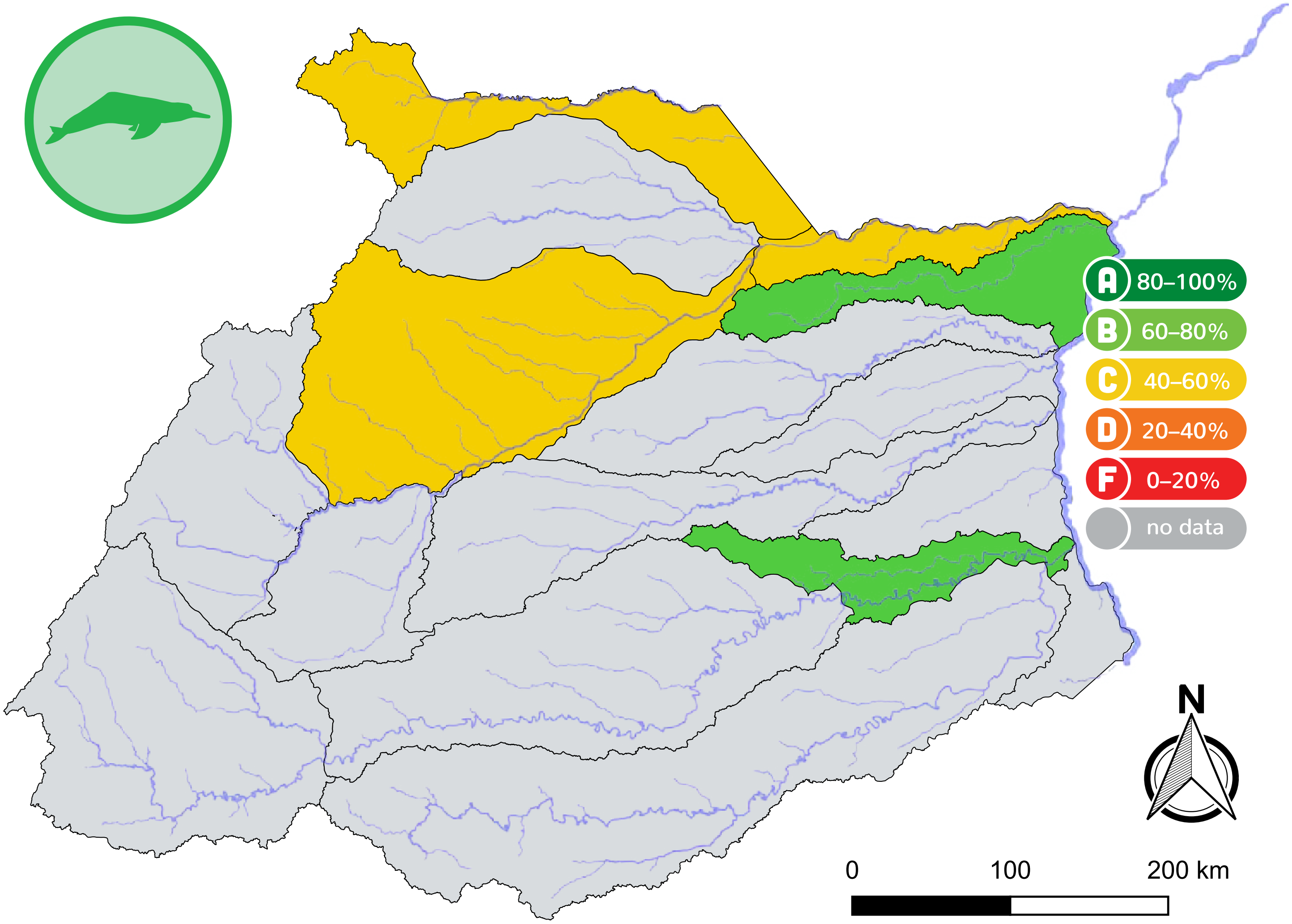


Figure 6-2. Map showing the dolphin abundance scores.

Table 6-2. Final dolphin abundance scores.

River basin	Score (0-100)
Arauca	53
Atabapo	Not applicable
Bita	60
Guaviare	
Upper	Not applicable
Middle	No data
Lower	63
Inirida	No data
Mataven	Not applicable
Meta	
Upper	Not applicable
Middle	41
Lower	41
Casanare	No data
Manacacias	Not applicable
Tomo	No data
Tuparro	No data
Vichada	No data

6.2 Others Biodiversity Indicators

During local workshops, stakeholders identified other key indicators that were not included in this version of the report card, due to lack of data availability. However, they remain important and could be featured in future report cards.

Indicators representing flora, mammals and fish were discussed in two workshops amongst experts from research institutes such as Humboldt and Sinchi; Universities including Javeriana, Unal, Tolima Quindio and Llanos; and NGOs including Panthera, Omacha Foundation and WWF. An outline of discussed potential indicators were:

Flora

Researchers from Sinchi Institute (Dairon Cardenas, Humberto Mendoza, Sonia Sua and Maria Fernanda Gonzalez) proposed a series of indicators according with the equation:

$$H_{sf} = B_i + P_i - B_{Ti}$$

where Hsf is the health status for the flora component. Bi is the Biodiversity index, calculated as the proportion of species registered (SR) Vs Species Estimated (SE) and the proportion of endemic species (ES) by area unit (A) in each sub basin i.

$$Bi = \frac{SR}{SE} + \left[\frac{ES_i}{A_i} * \frac{TES}{TA}\right]$$

Pi is the productivity index and was calculated based on the natural coverage and the proportion of use species (US) and the area unit (A) in each sub basin i and the total use species in the Orinoco (TUS) as follows:

$$Pi = \%\ natural\ coverage + \left[\frac{US_i}{A_i} * \frac{TUS}{TA}\right]$$

BTi is the index of biological threat and is calculated adding the proportion of Threatened Species (TS) and Invasive Species (IS) by area unit (A) in each sub basin i and the total invasive species in the Orinoco (TIS) as follows:

$$BTi = \left[\frac{TS_i}{A_i} * \frac{TTS}{TA}\right] + \left[\frac{IS_i}{A_i} * \frac{TIS}{TA}\right]$$

The information used is based on the Herbario Amazónico Colombiano (COAH), the Herbario Federico medem Bogotá (FMB), the Herbario Nacional Colombiano (COL) and the Global Information Facility (GBIF).

Mammals

Flora researchers from different institutions (Fernando Trujillo, Federico Mosquera-Guerra, Hugo Matilla-Meluk, Ángela Mejia and Esteban Payan) consolidated information about mammal richness and defined thresholds (High, Medium and Low) for the Meta, Bita, Inirida and Guaviare River basins. The methodology was based on the compilation of data from private, public and official biological data bases: the collection of the Instituto de Ciencias Naturales de la Universidad Nacional de Colombia (ICN), the Instituto Alexander von Humboldt (IAvH), the American Museum of Natural History (AMNH), the Field Museum of Natural History (FMNH), the Texas museum Tech University (TTU), the collection of the Smithsonian Institution (USNM) (Mantilla-Meluk in prep), the Javerian museum of natural history Lorenzo Uribe Uribe (MUJ) (Pérez-Torres et al. 2007) and Museo de Historia Natural Universidad Distrital Francisco José de Caldas (MUD) (Rodríguez- Bolaños in prep)

To calculate the index for each basin, the equation below and the thresholds were defined using three equal ranges (low, medium and high) between 0 and 1.

$$Bi = SE/SR$$

where:

$Bi = biodiversity\ index$

$SE = number\ of\ species\ estimated$

$SR = number\ of\ species\ observed\ or\ registered$

Fish

For fish, a historical data base compiled by various authors for Colombia (ICN-MHN, IAvH, CZUT, CIUA, CP-UCO, IMCN and MPUJ) and researches from Javeriana, National and Tolima University (Francisco Villa, Edwin Lopez, Javier Maldonado, Jose Ivan Mojica, between others) analyzed this data base that includes biological registers at national level since 1900. The method was based on identifying the number of species in each river basin and, according with the historical register, accumulation curves were developed (Figure 6-3). Based on these curves, the next step was to estimate the potential maximum number of species in each river basin according with the Hill model (Withers 1992) and finally define thresholds for each basin using three ranges of quartiles (Low, Medium and high).

In summary, the effort to compile and systematize biological information was important during report card development. Currently, the Orinoco River basin could be the place in Colombia where gaps of data on biodiversity is better known. However, after internal discussions this valuable information was not used in the report card, because the information compiled reflects historical base line information rather than the current status of biodiversity. It shows us the need to harmonize monitoring systems on biodiversity at the national level in Colombia.

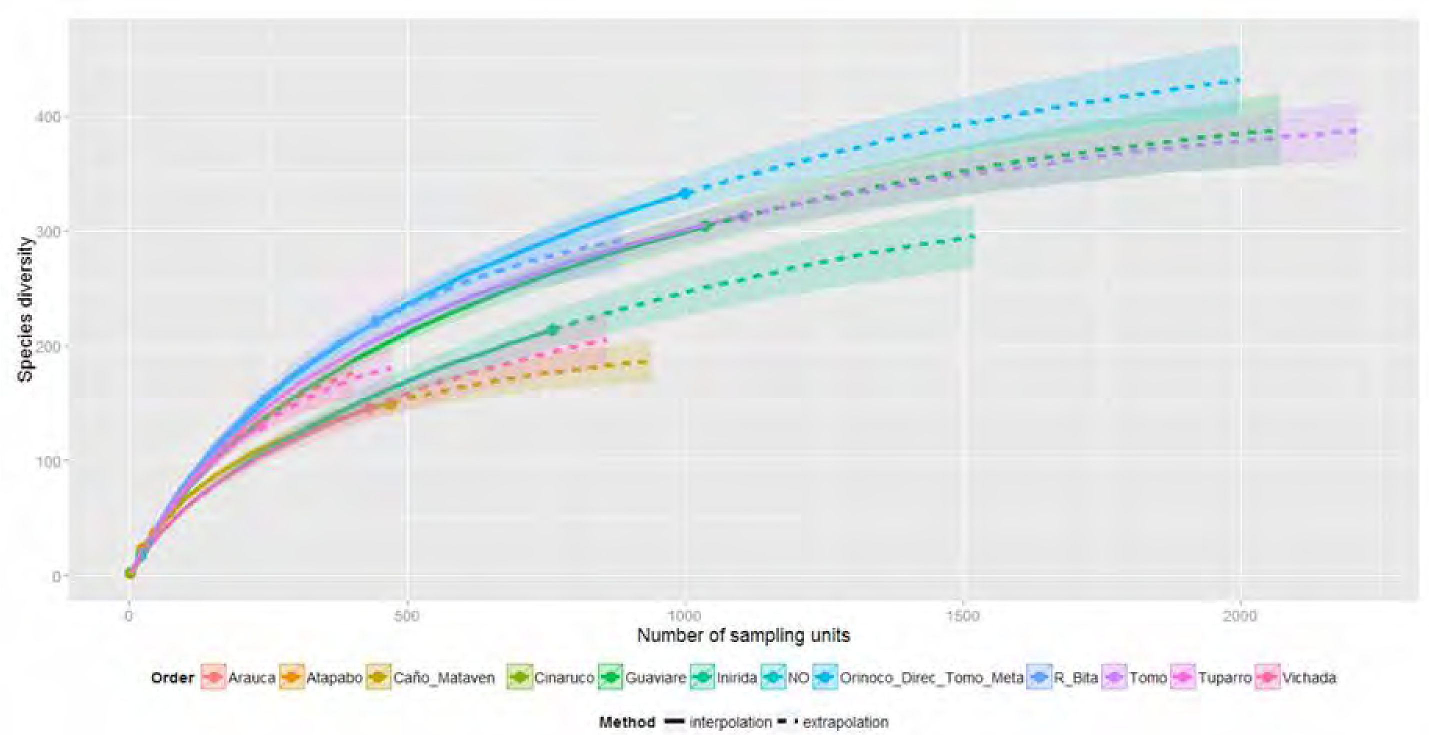


Figure 6-3. Species accumulation curves for each subbasin, using the Hill model

7 Summary of report card scores and grades

7.1 Overall Orinoco River

Overall the Orinoco River basin received a B- (63%). Results varied widely, with generally better results for indicators within Ecosystems & Landscapes and Water categories, than indicators from the Biodiversity, People & Culture and Management & Governance categories. However, it is important to note that the poorer scoring categories also had the fewest indicators due to limited data availability. Overall basin scores ranged from as low as 39% for Water Quality, to as high as 93% for Stable Forest Area (representing intact forests between 1990-2014 in the Amazon-Orinoco transition zone).

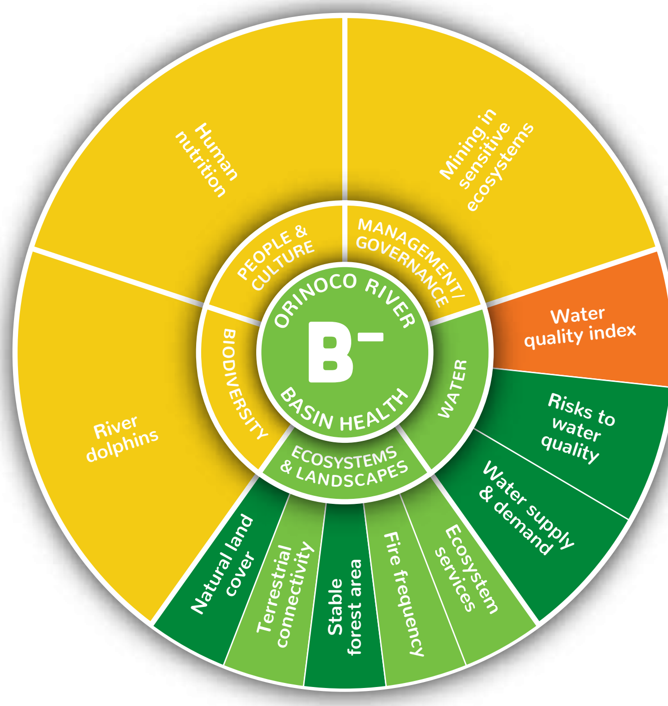


Figure 7-1. Figure showing the indicator, values, and overall Orinoco scores.

Table 7-1. Orinoco River Report Card indicators, values, and scores.

Sub-basin	Water	Ecosystems and Landscapes	People and Culture	Management/ Governance	Biodiversity
Arauca	74	79	47	0	53
Atabapo	90	93	38	67	N/A
Bita	87	80	53	75	60
Upper Guaviare	69	62	44	50	NA
Lower Guaviare	80	94	49	60	63
Mid Guaviare	83	90	46	60	NA
Inirida	81	92	31	67	ND
Mataven	100	95	53	100	NA
Upper Meta Alto	52	41	39	17	NA
Lower Meta	74	86	53	100	41
Meta Casanare	67	70	49	0	NA
Meta Manacacias	84	55	46	40	NA
Mid Meta	66	70	51	17	41
Tomo	98	86	53	100	ND
Tuparro	90	89	53	75	ND
Vichada	81	87	50	25	ND

ND = no data; NA = Not applicable

7.2 Orinoco River Basins

At the sub-basin scale, results showed a strong west-east gradient where the Upper Meta had the poorest grade, D+ (37%), and Matavén had the highest grade, A (87%). The differences between western and eastern portions of the Orinoco River Basin are due to development pressure in the west, resulting in poorer water quality, and significant changes to the landscape.

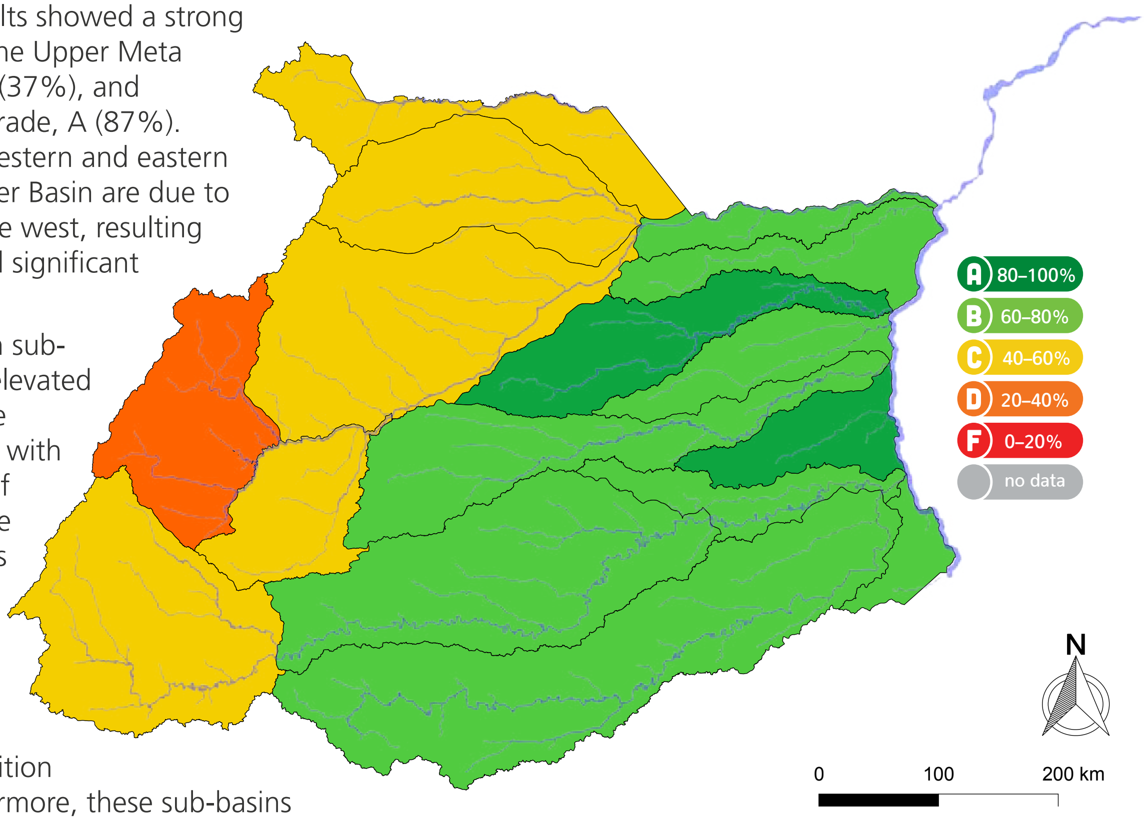


Figure 7-2. Map showing the overall Orinoco scores.

Notable changes in Andean sub-basins in the west include elevated rates of deforestation in the Upper Guaviare, associated with poor water quality; a lack of terrestrial connectivity in the Upper Meta; major changes in the fire regime in the Meta Manacacías; low water quality and mining for construction materials in Casanare, as well as below average human nutrition in the Arauca basin. Furthermore, these sub-basins have undergone significant agro-industrial expansion, oil and gas exploitation, urbanization, and intensive livestock activities.

The Llanos and Amazon transition sub-basins to the south and east were not immune to poor scores with the Inírida sub-basin receiving the poorest score (31%) for human nutrition (based on the weight of 0-4 year-old children), and the Vichada scoring poorly (25%) for mining of construction materials for new infrastructure, mainly related to the oil boom in the region.

Sub-basin Average	Basin Area (ha)	% Total Basin	Area-weighted contribution to overall score	Overall Orinoco Score	Overall Orinoco Grade
51	1,645,221	4.7%	2	63	B-
72	464,273	1.3%	1		
71	1,242,930	3.6%	3		
56	3,552,061	10.2%	6		
69	885,598	2.6%	2		
70	4,019,387	11.6%	8		
68	5,379,528	15.5%	11		
87	1,051,320	3.0%	3		
37	2,212,372	6.4%	2		
71	635,474	1.8%	1		
47	2,401,300	6.9%	3		
56	1,416,497	4.1%	2		
49	4,007,708	11.5%	6		
84	2,030,101	5.8%	5		
77	1,155,860	3.3%	3		
61	2,621,200	7.5%	5		

Arauca River

The Arauca River Basin received an overall C grade (51%). Of the nine indicators assessed, results varied widely, with generally better results for indicators representing the categories Ecosystems & Landscapes and Water. Lower scores were received by indicators representing Biodiversity, People & Culture, and Management/Governance, with the indicator of most concern being mining in sensitive ecosystems. However, many of the lower scoring categories also had the fewest indicators due to data limitations. Also, no water quality sites in the basin are currently included in IDEAM's National Network Monitoring Program, so this indicator could not be included due to insufficient data.

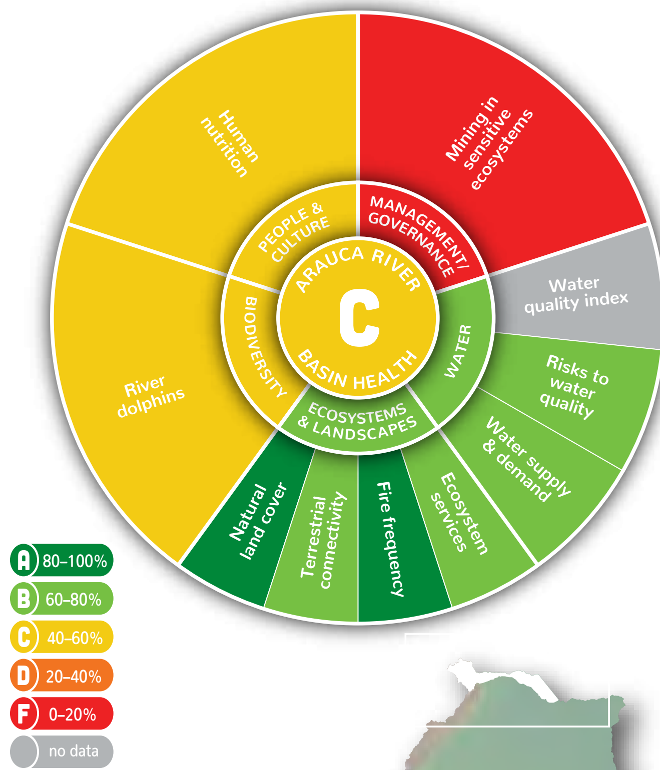


Table 7-3. Arauca River Report Card indicators, values, and scores.

Values	Indicators	Indicator Score (%)	Value Score (%)	Overall Score (%)	Overall Grade
Water	Water quality index		74	51	C
	Risk to water quality index	69			
	Water supply and demand	78			
Ecosystems & Landscapes	Natural land cover	81	79		
	Stable forest area				
	Fire frequency	95			
	Terrestrial connectivity	72			
	Ecosystem services	69			
People & Culture	Human nutrition	47	47		
Management & Governance	Mining in sensitive ecosystems	0	0		
Biodiversity	Dolphin abundance	53	53		

Atabapo River

The Atabapo River Basin received an overall B grade (72%). Of the eight indicators assessed, most scored in the good-excellent range, except for the human nutrition indicator which had the second-lowest score in all of the Orinoco River Basin. Overall basin scores ranged from as low as 38% for human nutrition, to as high as 100% for both water supply and demand, and natural land cover. The condition of stable forest area, terrestrial connectivity, and risks to water quality were also excellent in the Atabapo River Basin. Unfortunately, none of IDEAM's National Network Monitoring Program water quality sites are currently within the Atabapo River, so the water quality index was not available for this sub-basin. There is currently no biodiversity indicator. The main biodiversity indicator in the other sub-basins was river dolphins, but due to the type of water, length/depth of the river, and fish abundance, river dolphins are not naturally present in this river.

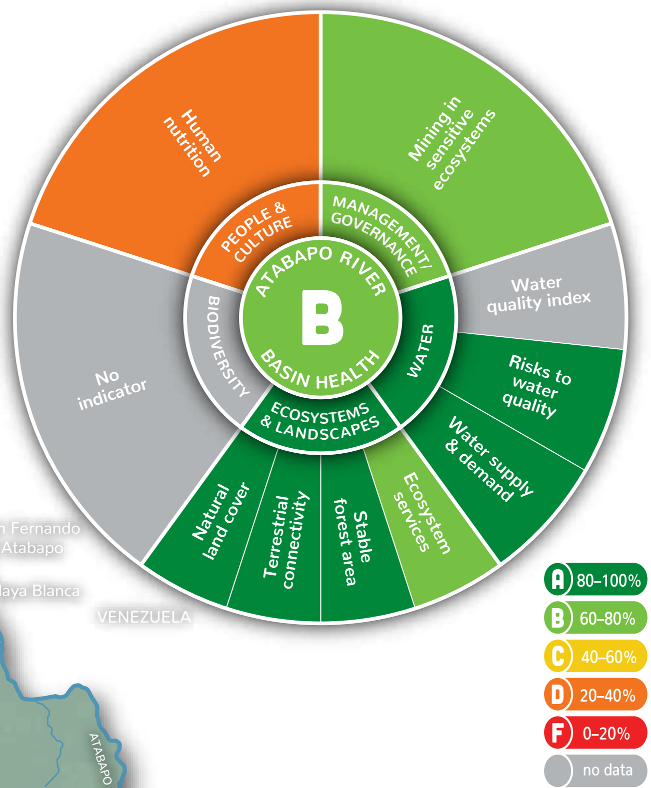
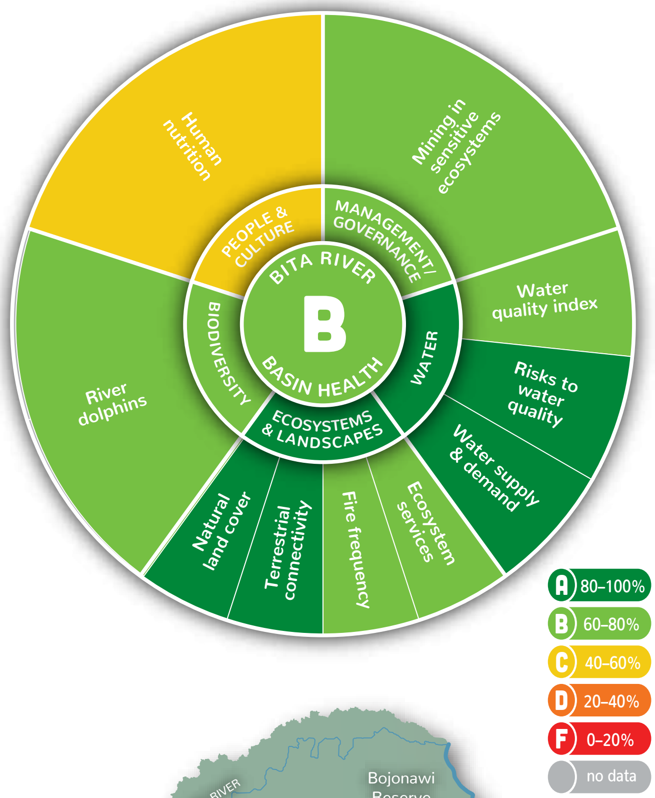


Table 7-4. Atabapo River Report Card indicators, values, and scores.

Values	Indicators	Indicator Score (%)	Value Score (%)	Overall Score (%)	Overall Grade
Water	Water quality index		90	72	B
	Risk to water quality index	80			
	Water supply and demand	100			
Ecosystems & Landscapes	Natural land cover	100	93		
	Stable forest area	97			
	Fire frequency				
	Terrestrial connectivity	97			
	Ecosystem services	77			
People & Culture	Human nutrition	38	38		
Management & Governance	Mining in sensitive ecosystems	67	67		
Biodiversity	Dolphin abundance				

Bita River

The Bita River Basin received an overall B grade (71%). Of the ten indicators assessed, most scored in the good-excellent range, except for a moderate score for the human nutrition indicator. Overall basin scores ranged from as low as 53% for human nutrition, to as high as 100% for risk to water quality, with water supply and demand, natural land cover, and terrestrial connectivity all excellent. The water quality score (64%) wasn't as high as expected considering the intact nature of the basin. This suggests that the expansion of industrialized agricultural and livestock projects are degrading water quality within the river basin.



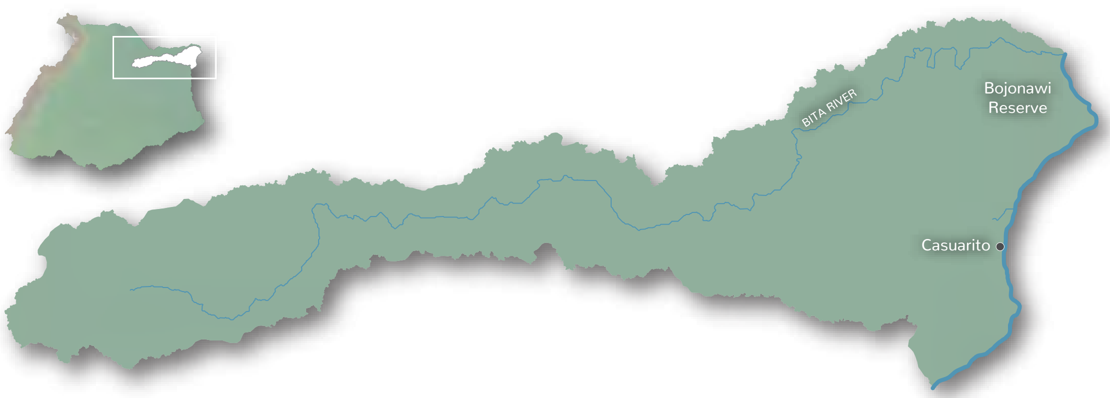
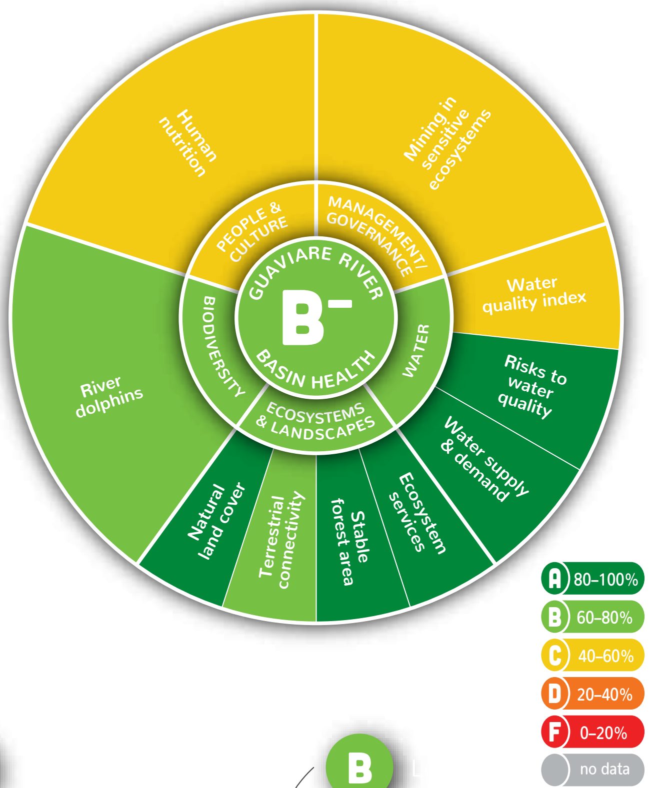


Table 7-5. Bita River Report Card indicators, values, and scores.

Values	Indicators	Indicator Score (%)	Value Score (%)	Overall Score (%)	Overall Grade
Water	Water quality index	64	87	71	B
	Risk to water quality index	100			
	Water supply and demand	96			
Ecosystems & Landscapes	Natural land cover	98	80		
	Stable forest area				
	Fire frequency	62			
	Terrestrial connectivity	95			
	Ecosystem services	64			
People & Culture	Human nutrition	53	53		
Management & Governance	Mining in sensitive ecosystems	75	75		
Biodiversity	Dolphin abundance	60	60		

Guaviare River



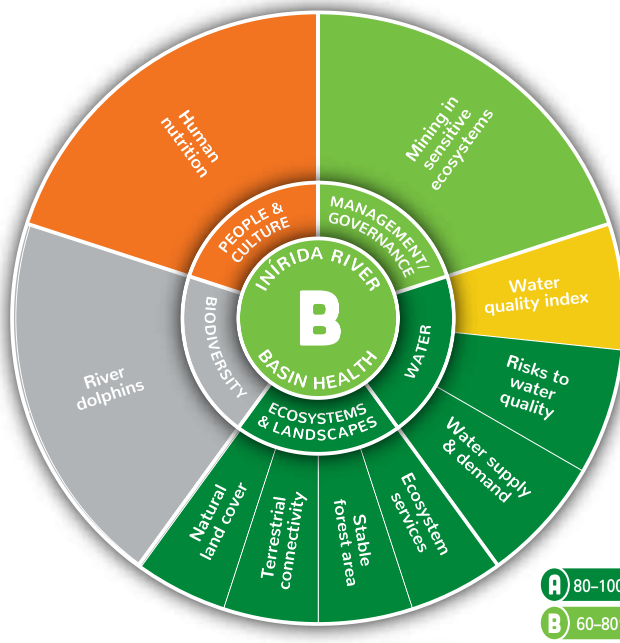
The Guaviare River Basin received an overall area-weighted average grade of B- (64%), with the Upper Guaviare receiving a C+ (56%), and the Middle and Lower Guaviare receiving a B (70% and 69%, respectively). There was a mix of moderate, good, and excellent results for the ten indicators assessed. Overall basin scores ranged from as low as 45% for water quality and human nutrition, to 95% for water supply and demand. Overall the sub-basin had excellent scores for risk to water quality (90%), water supply and demand (95%), natural land cover (85%), stable forest area (87%), and ecosystem services (82%). However the overall score for the entire sub-basin, is not representative of each of the three reporting regions, with very poor scores in the Upper Guaviare for terrestrial connectivity (23%) and water quality (35%). Mining for construction materials and limestone in and around the Ariari River, near the Macarena Range, is likely contributing to both the poor water quality observed in the Upper Guaviare, as well as the lowest score for stable forest area (76%) in the entire Orinoco River Basin.

Table 7-6. Guaviare River Report Card indicators, values, and scores.

Values	Indicators	Indicator Score (%)	Value Score (%)	Overall Score (%)	Overall Grade
Water	Water quality index	45	77	64	B-
	Risk to water quality index	90			
	Water supply and demand	95			
Ecosystems & Landscapes	Natural land cover	85	79		
	Stable forest area	87			
	Fire frequency				
	Terrestrial connectivity	60			
	Ecosystem services	82			
People & Culture	Human nutrition	45	45		
Management & Governance	Mining in sensitive ecosystems	56	56		
Biodiversity	Dolphin abundance	63	63		

Inirida River

The Inírida River Basin received an overall B grade (68%). Of the nine indicators assessed, scores were excellent (>80%) for risk to water quality, water supply and demand, and for the all indicators within the category Ecosystems & Landscapes. However, the basin did have the lowest score in all of the Orinoco River Basin for human nutrition (31%) and moderate results for the water quality index (57%). The low score for human nutrition is likely due in part to the low richness of fish and therefore lower food supply as compared with other Andean sub-basins. The low water quality index can be attributed largely to limnology changes that result from mining activities. Although no river dolphin data was analyzed for this version of the report card, due to lack of data around the Puinawai and Nukak Natural Reserves, new information on river dolphin abundance will become available soon for future report cards.



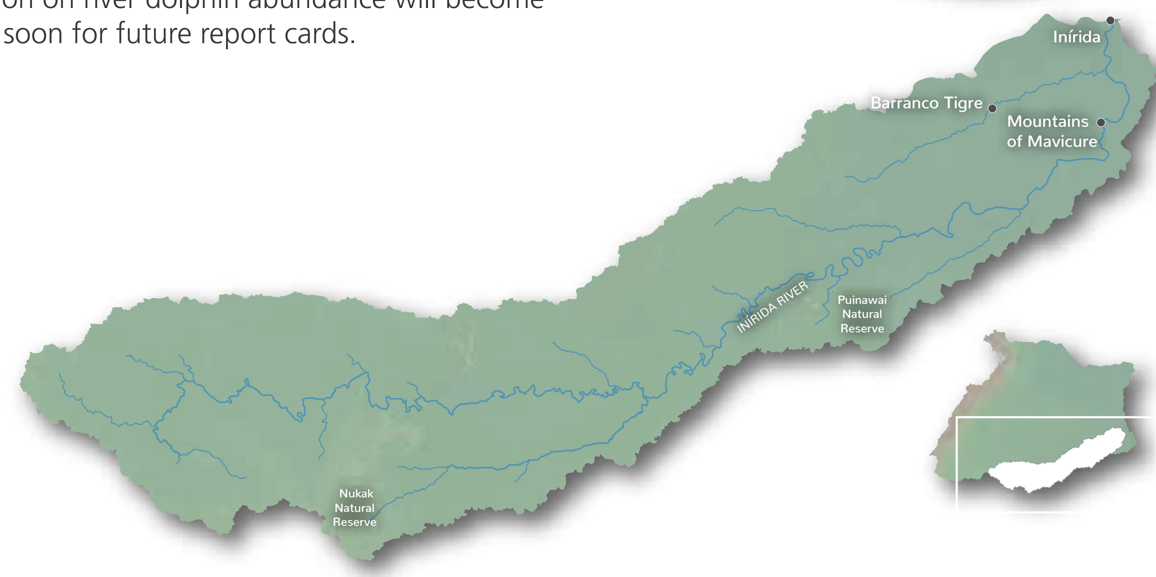
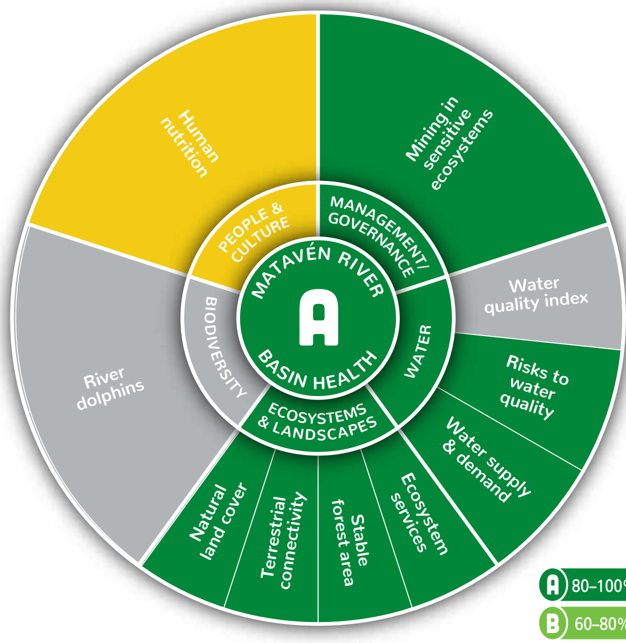


Table 7-7. Inirida River Report Card indicators, values, and scores.

Values	Indicators	Indicator Score (%)	Value Score (%)	Overall Score (%)	Overall Grade
Water	Water quality index	57	81	68	B
	Risk to water quality index	87			
	Water supply and demand	99			
Ecosystems & Landscapes	Natural land cover	97	92		
	Stable forest area	97			
	Fire frequency				
	Terrestrial connectivity	88			
	Ecosystem services	87			
People & Culture	Human nutrition	31	31		
Management & Governance	Mining in sensitive ecosystems	67	67		
Biodiversity	Dolphin abundance				

Mataven River

The Matavén River Basin received an overall A grade (87%), the highest of all the sub-basins within the Colombian portion of Orinoco River Basin. Of the eight indicators assessed, all were excellent (>80%) except for human nutrition (53%) which despite its moderate score was still the best score for this indicator in the Orinoco River Basin. Perfect scores were achieved for risks to water quality, water supply and demand, natural land cover, and mining in sensitive ecosystems. Though this basin received exceptional grades, there are major data gaps that need to be filled. Currently IDEAM's National Network Monitoring has not water quality monitoring sites for the river. Additionally, no biodiversity data was available for this version of the report card, making this is a priority area of research for future report cards.



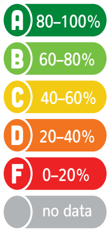
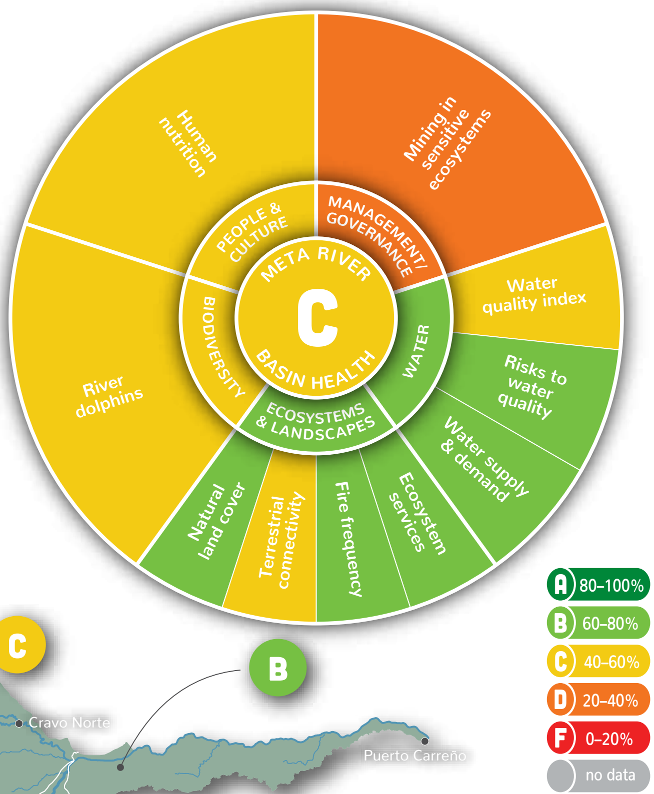


Table 7-8. Mataven River Report Card indicators, values, and scores.

Values	Indicators	Indicator Score (%)	Value Score (%)	Overall Score (%)	Overall Grade
Water	Water quality index		100	87	A
	Risk to water quality index	100			
	Water supply and demand	100			
Ecosystems & Landscapes	Natural land cover	100	95		
	Stable forest area	98			
	Fire frequency				
	Terrestrial connectivity	97			
	Ecosystem services	85			
People & Culture	Human nutrition	53	53		
Management & Governance	Mining in sensitive ecosystems	100	100		
Biodiversity	Dolphin abundance				

Meta River



The Meta River Basin received an overall area-weighted average grade of C (48%), with the Upper Meta receiving a D+ (37%), Meta Manacacías a C+ (56%), Middle Meta a C (49%), Casanare a C (47%), and Lower Meta receiving a B (71%). This represents a strong transition in the health of the basin with poorer conditions in the western Andean portion and better conditions towards the eastern plains, which is still unfortunately impacted by poor upstream conditions.

Overall basin scores ranged from as low as 21% for mining in sensitive ecosystems, to 76% for risks to water quality. The overall scores for the entire sub-basin, however, do not reflect the full story about the conditions in specific areas. Poor scores in different parts of the basin result from region-specific resource exploitation patterns. For example, failing scores in the Upper Meta for terrestrial connectivity are due to historical fragmentation of the landscape.

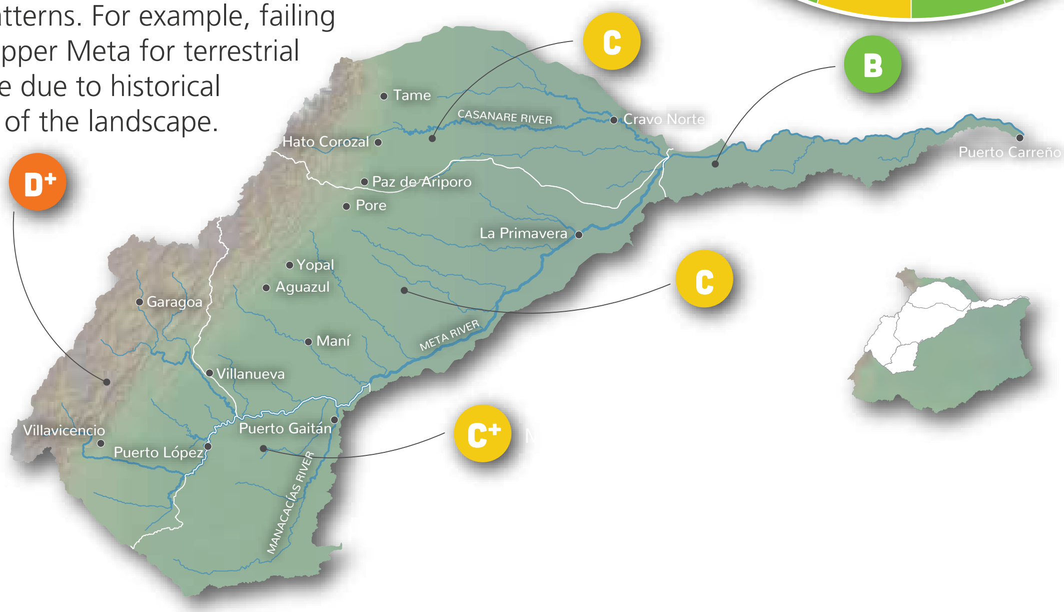


Table 7-9. Meta River Report Card indicators, values, and scores.

Values	Indicators	Indicator Score (%)	Value Score (%)	Overall Score (%)	Overall Grade
Water	Water quality index	45	66	48	C
	Risk to water quality index	76			
	Water supply and demand	73			
Ecosystems & Landscapes	Natural land cover	72	63		
	Stable forest area				
	Fire frequency	63			
	Terrestrial connectivity	49			
	Ecosystem services	67			
People & Culture	Human nutrition	48	48		
Management & Governance	Mining in sensitive ecosystems	21	21		
Biodiversity	Dolphin abundance	41	41		

Tomo River

The Tomo River Basin received an overall A- grade (84%), the second highest of all the sub-basins within the Colombian portion of Orinoco River Basin. Of the eight indicators assessed, all were excellent (>80%) with the exception of ecosystem services (63%) and the human nutrition (53%). These lower scores are likely due to very poor soil fertility and changes in indigenous nomadic traditions. A noteworthy score of 100% was achieved for risk to water quality, and mining in sensitive ecosystems which is a positive indication that this basin is experiencing low pressures. There is, however, a need to know more. There are currently no IDEAM National Network Monitoring water quality sites making the water quality index unavailable for this sub-basin. Additionally, no river dolphin data was available for this version of the report card, but it is anticipated that new information on river dolphin abundance will become available for future report cards.

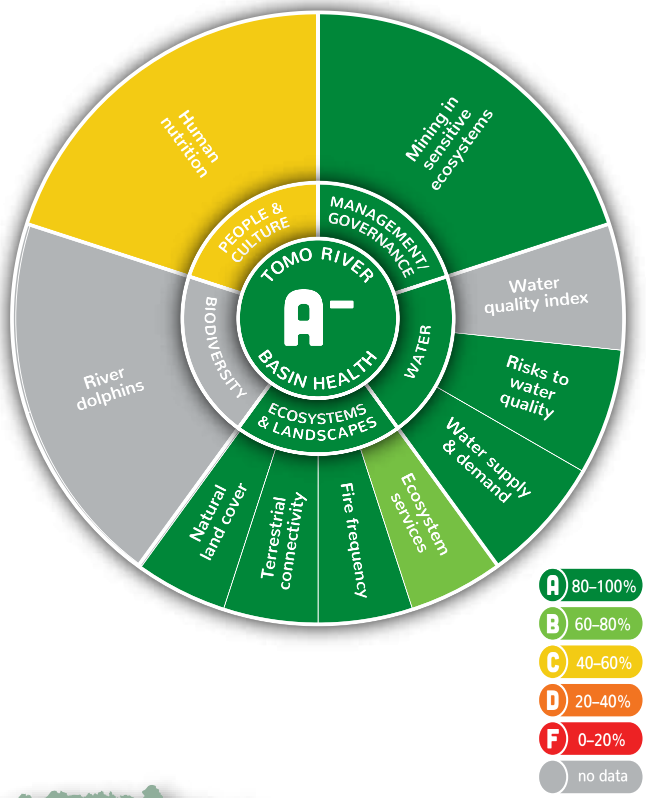
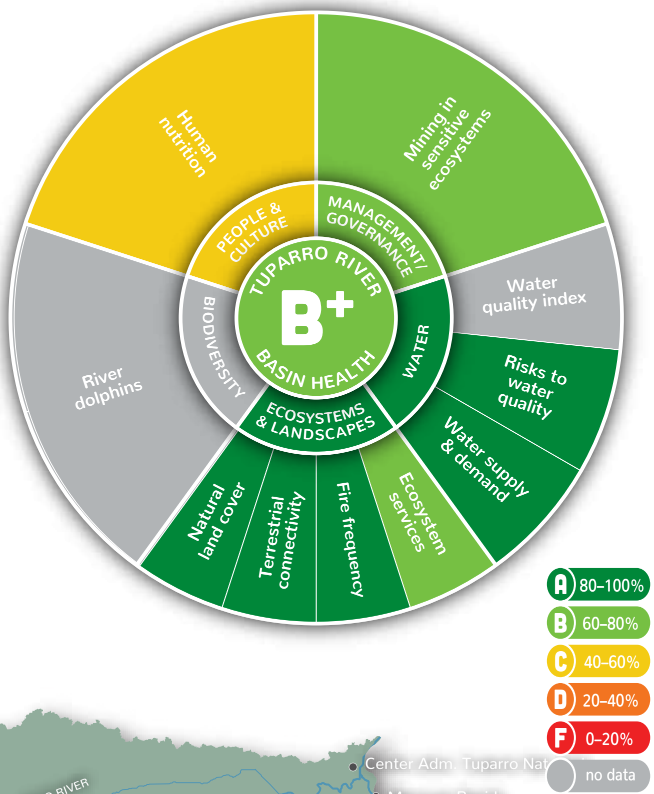


Table 7-10. Tomo River Report Card indicators, values, and scores.

Values	Indicators	Indicator Score (%)	Value Score (%)	Overall Score (%)	Overall Grade
Water	Water quality index		98	84	A-
	Risk to water quality index	100			
	Water supply and demand	96			
Ecosystems & Landscapes	Natural land cover	93	86		
	Stable forest area				
	Fire frequency	95			
	Terrestrial connectivity	91			
	Ecosystem services	63			
People & Culture	Human nutrition	53	53		
Management & Governance	Mining in sensitive ecosystems	100	100		
Biodiversity	Dolphin abundance				

Tuparro River

The Tuparro River Basin received the third highest score of all the sub-basins within the Colombian portion of Orinoco River Basin, with an overall B+ grade (77%). Of the eight indicators assessed, all were excellent (>80%) or good (60-80%) except for human nutrition (53%) which despite its moderate score was the best score for human nutrition within the Orinoco River Basin. A score of 100% was achieved for natural land cover. No IDEAM National Network Monitoring Program water quality sites are currently within the Tuparro River, so water quality information was not available for this sub-basin. No river dolphin data was available for this version of the report card, but new information on river dolphin abundance will become available for future report cards.



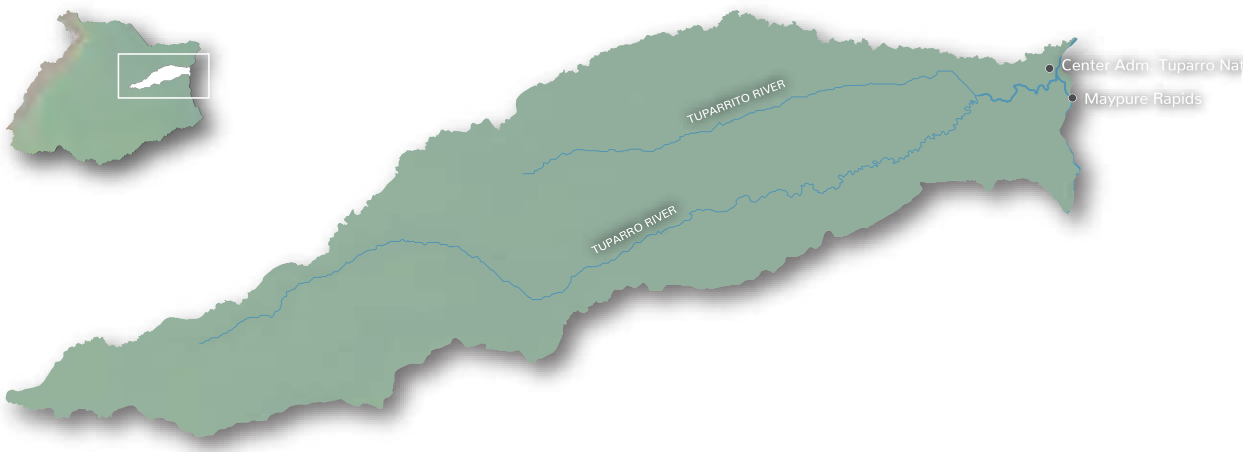


Table 7-11. Tuparro River Report Card indicators, values, and scores.

Values	Indicators	Indicator Score (%)	Value Score (%)	Overall Score (%)	Overall Grade
Water	Water quality index		90	77	B+
	Risk to water quality index	80			
	Water supply and demand	99			
Ecosystems & Landscapes	Natural land cover	100	89		
	Stable forest area				
	Fire frequency	91			
	Terrestrial connectivity	97			
	Ecosystem services	67			
People & Culture	Human nutrition	53	53		
Management & Governance	Mining in sensitive ecosystems	75	75		
Biodiversity	Dolphin abundance				

Vichada River

The Vichada River Basin received an overall B- grade (61%). Of the nine indicators assessed, all were excellent (>80%) or good (60-80%) except for human nutrition (50%) and mining in sensitive ecosystems (25%), the latter reflecting the level of mineral and hydrocarbon exploitation in the western headwater portion of the Vichada River Basin, mainly in the Puerto Gaitan municipality. The contradiction between the excellent indicator scores for the current state of ecosystems and landscapes and the very low scores for indicators of mining in sensitive ecosystem suggests that either exploitation activities are not yet impacting the river basin or that monitoring is not capturing these impacts, making this an issue that will be useful to track in future report cards. No biodiversity data was available for this version of the report card, but it is anticipated that new information on river dolphin abundance will become available for future report cards.

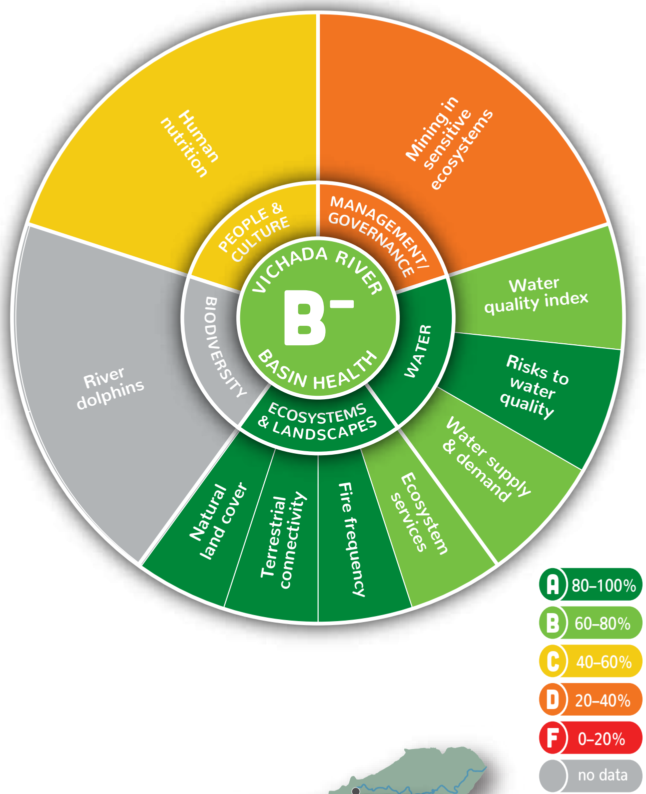


Table 7-12. Vichada River Report Card indicators, values, and scores.

Values	Indicators	Indicator Score (%)	Value Score (%)	Overall Score (%)	Overall Grade
Water	Water quality index	63	81	61	B-
	Risk to water quality index	100			
	Water supply and demand	79			
Ecosystems & Landscapes	Natural land cover	93	87		
	Stable forest area				
	Fire frequency	96			
	Terrestrial connectivity	88			
	Ecosystem services	69			
People & Culture	Human nutrition	50	50		
Management & Governance	Mining in sensitive ecosystems	25	25		
Biodiversity	Dolphin abundance				

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Appendix I - Fire frequency deciles 2001-2012

Decile	Score	Arauca	Bita	Upper Meta	Middle Meta	Lower Meta	Meta Casanare
100	0	1279	1143	417	2318	1056	2057
90	20	995	1052	323	2191	874	1978
80	40	886	956	204	2076	821	1661
70	60	875	946	186	1619	742	1558
60	80	835	902	168	1565	704	1300
50	100	751	829	151	1512	683	1128
40	80	668	800	138	1416	674	1025
30	60	625	705	109	1213	660	917
20	40	604	630	84	1098	650	762
10	20	588	572	79	1070	497	728
0	0	469	502	76	886	422	612

Decile	Score	Meta Manacacias	Tomo	Tuparro	Vichada
100	0	1969	2714	1487	3666
90	20	1783	2467	1370	3332
80	40	1547	2175	982	2944
70	60	1328	1891	959	2412
60	80	1216	1811	907	2310
50	100	1114	1746	819	2180
40	80	1069	1602	764	1977
30	60	1003	1518	688	1888
20	40	964	1423	664	1858
10	20	920	1306	617	1810
0	0	880	1179	535	1688

Green highlighted cells denote average fire frequency range for 2013-2015.

Appendix II - Basin and Department Areas

Basin Name	Basin Area (ha)	Department	Department Area (ha)	% Department Area within Basin
Guaviare Upper	3552060.93	META	3205469.93	90.24
		GUAVIARE	346591.00	9.76
Meta Upper	2212372.12	BOYACA	528657.00	23.90
		CASANARE	57021.30	2.58
		CUNDINAMARCA	711380.20	32.15
		META	915313.62	41.37
Guaviare Lower	885598.00	GUAINIA	205403.00	23.19
		VICHADA	680195.00	76.81
Meta Lower	635474.06	ARAUCA	26156.90	4.12
		VICHADA	609317.16	95.88
Meta Casanare	2401299.53	ARAUCA	1354270.00	56.40
		BOYACA	15367.70	0.64
		CASANARE	1031661.83	42.96
Guaviare Middle	4019387.00	GUAINIA	609053.00	15.15
		GUAVIARE	476824.00	11.86
		META	1360890.00	33.86
		VICHADA	1572620.00	39.13
Meta Middle	4007707.60	BOYACA	317983.00	7.93
		CASANARE	3339280.00	83.32
		META	91076.60	2.27
		VICHADA	259368.00	6.47
Meta Manacacias	1416497.07	META	1416497.07	100.00
Arauca	1645221.20	ARAUCA	1000220.00	60.80
		BOYACA	235089.00	14.29
		NORTE DE SANTANDER	343121.00	20.86
		SANTANDER	66791.20	4.06
Atabapo	464273.08	GUAINIA	464273.08	100.00
Bita	1242930.00	VICHADA	1242930.00	100.00
Inirida	5379527.79	GUAINIA	2886710.00	53.66
		GUAVIARE	2229201.79	41.44
		VAUPES	263616.00	4.90

Mataven	1051320.00	VICHADA	1051320.00	100.00
Tomo	2030101.20	META	41681.20	2.05
		VICHADA	1988420.00	97.95
Tuparro	1155860.00	VICHADA	1155860.00	100.00
Vichada	2621200.00	META	1171570.00	44.70
		VICHADA	1449630.00	55.30


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