AGUAS AMAZÓNICAS ALIANZA

Integridad ecológica en la Cuenca Amazónica: avances en el modelo conceptual y en la propuesta de monitoreo participativo

Ecological Integrity in the Amazon Basin: Advances in the Conceptual Model and the Participatory Monitoring Proposal

USFQ

Instituto de Desenvolvimento Sustentável Mamirauá

AGUAS AMAZÓNICAS

CON EL APOYO DE GORDON AND BETTY MOORE FOUNDATION

WCS

SAWA-Connect

Apoyar a la Alianza por las Aguas de la Amazonía en la movilización de conocimiento y acción colaborativa para conservar la integridad y la conectividad de los ecosistemas de agua dulce amazónicos.

Support the Amazon Waters Alliance in mobilizing collaborative knowledge and action to conserve the integrity and connectivity of Amazon Freshwater Ecosystems

1. ***Marco Conceptual de Integridad Ecológica***
2. ***Monitoreo Participativo de Ecosistemas de Agua Dulce***

Objetivo general

Para 2026, la Alianza de Aguas Amazónicas fortalecerá el conocimiento sobre los sistemas de agua dulce amazónicos y su gestión, generando y compartiendo evidencia aplicable sobre peces, agua y variables clave con los actores involucrados.

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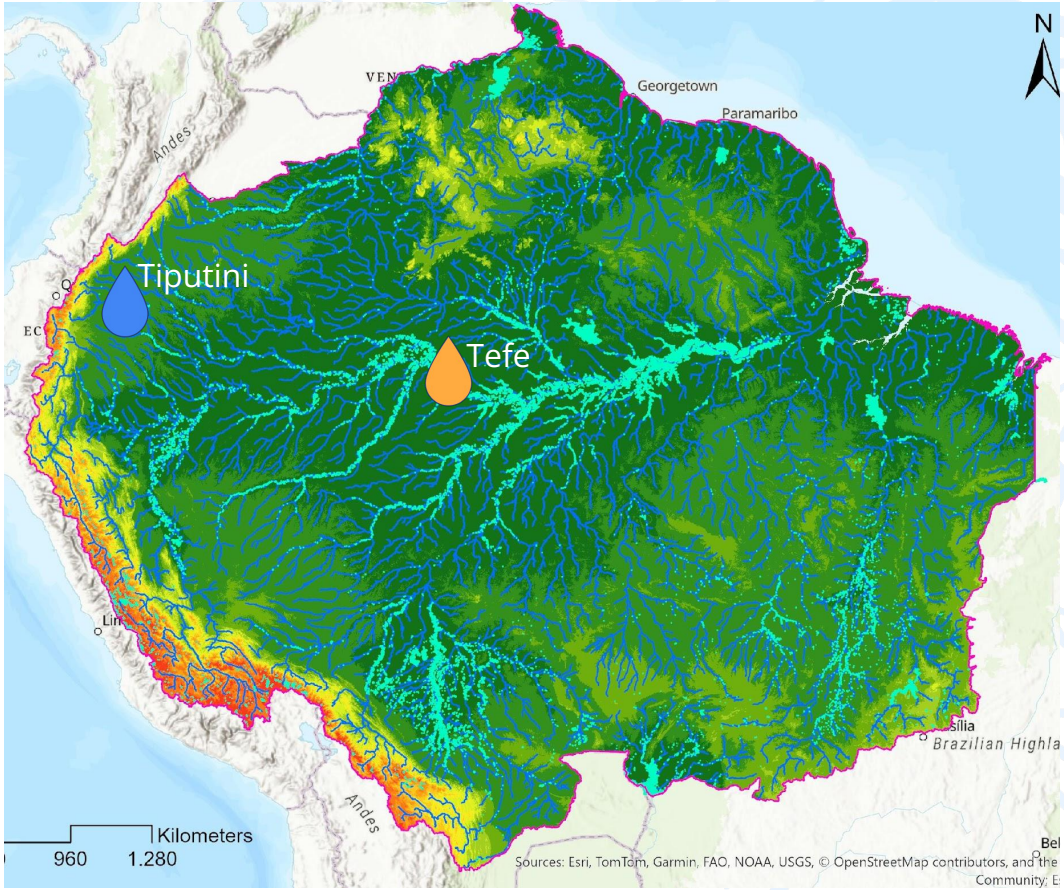
SAWA Objetivo específico 1

Crear un **Marco Conceptual** que se base en las Metas de Conservación establecidas para sintetizar, actualizar regularmente y comunicar mensajes clave sobre el **estado de los sistemas ecológicos de agua dulce** de la Amazonía a múltiples escalas (biodiversidad, hidrología, **conectividad**, factores de cambio y gestión efectiva, entre otros).

SAWA Objetivo específico 2



Diseñar, probar en campo y completar una **Prueba de Concepto para el Monitoreo Participativo del Agua** y la gestión de ecosistemas de agua dulce en al menos dos sitios ubicados en subcuencas clave: el Napo, en el gradiente Andes-Amazonía (río Tiputini), y el Medio Solimões en la Amazonía baja (lago Tefé).

SAWA Objetivo específico 1

Crear un **Marco Conceptual** que se base en las Metas de Conservación establecidas para sintetizar, actualizar regularmente y comunicar mensajes clave sobre el **estado de los sistemas ecológicos de agua dulce** de la Amazonía a múltiples escalas (biodiversidad, hidrología, **conectividad**, factores de cambio y gestión efectiva, entre otros).

Conceptual Framework

Ecological integrity is defined as the capacity of an ecosystem to support and maintain a balanced, resilient, and adaptive community of organisms that reflects its natural evolutionary and ecological processes (Groves et al., 2002)

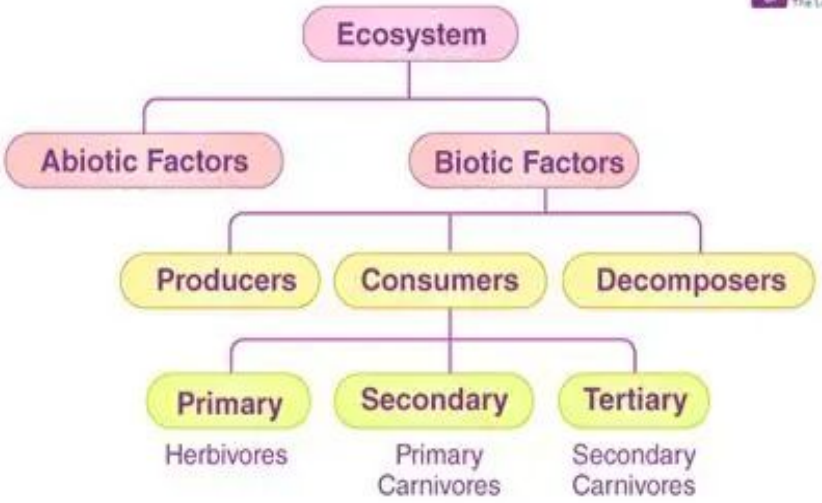
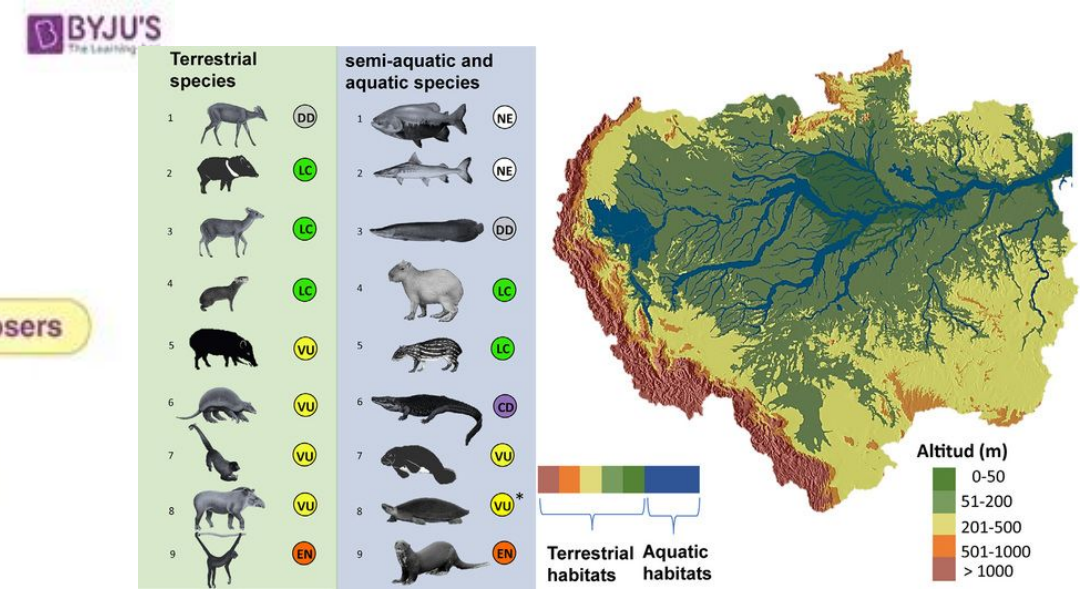


Diagram of Ecosystem Structure (byjus.com/biology/ecosystem/)



Campos-Silva et al. 2017

Aquatic Ecological Integrity of the Amazon

TEMPORAL

Structure: represents the physical template that shapes freshwater dynamics in the Amazon.

- Flood regime
- Longitudinal connectivity
- Floodplain inundation

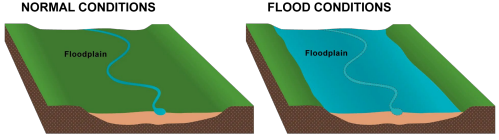
Function: captures the ecological processes that sustain ecosystem services and resilience.

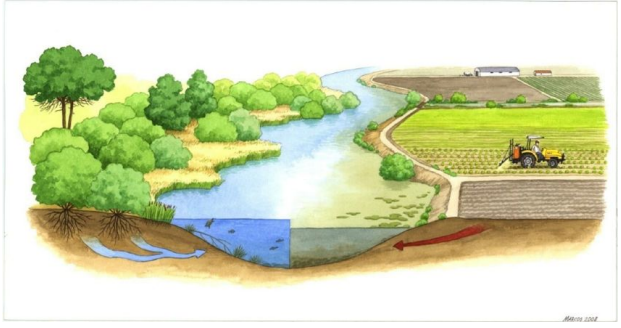
- Riparian cover
- Vegetation cover
- Water temperature

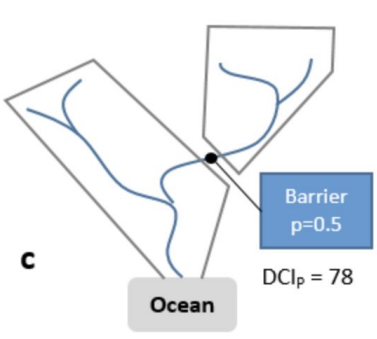
SPATIAL

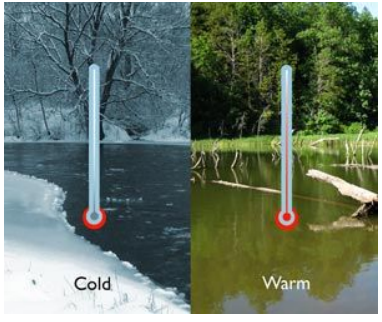
Composition: key indicator of ecosystem integrity

- Diversity





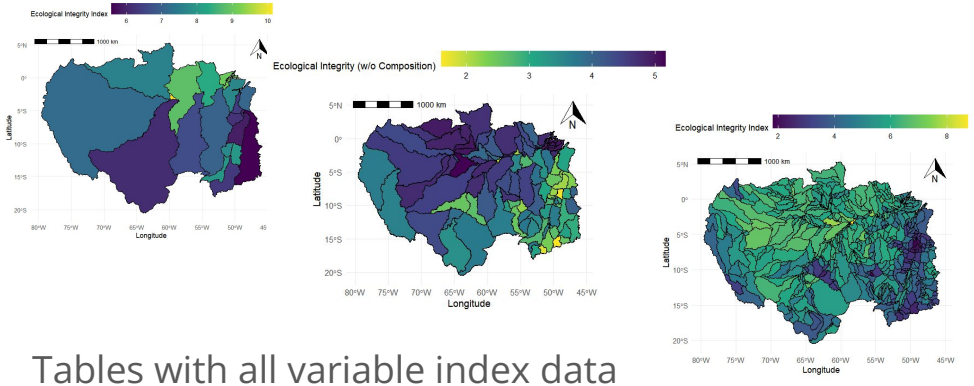




Framework Development

Phase 1:

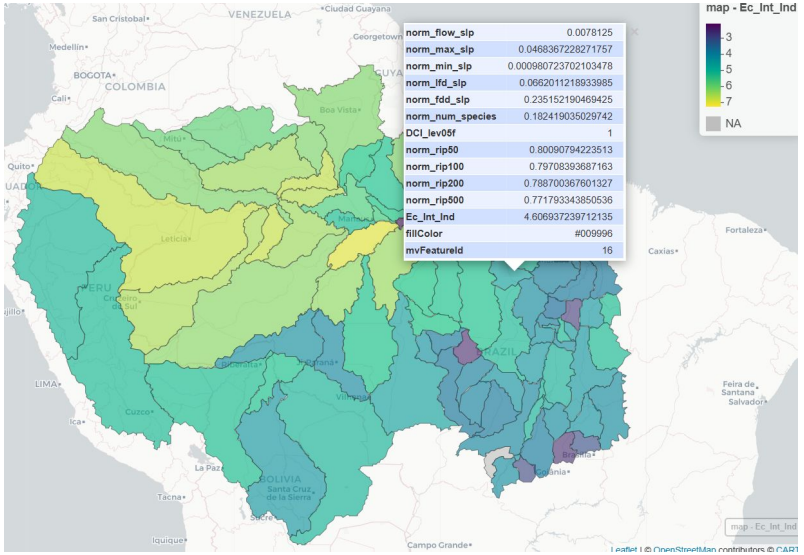
Static Maps presenting Ecological Integrity Index for Level 4, 5, 6 basins



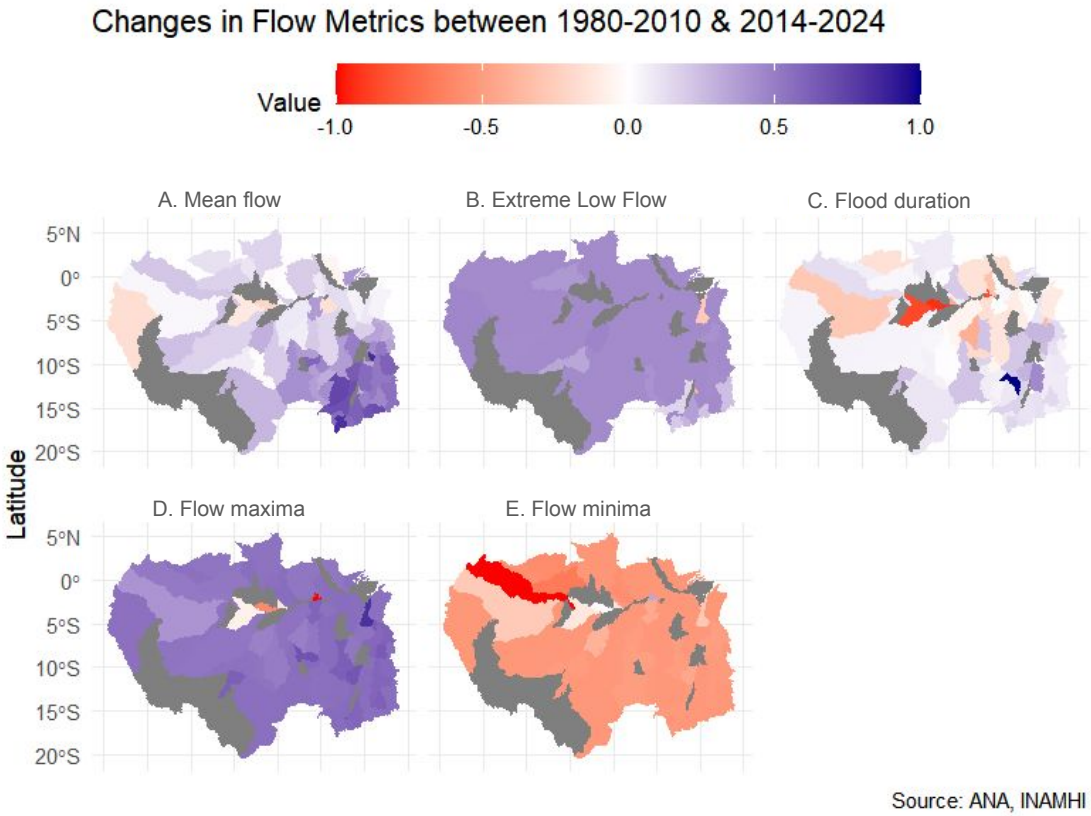
Tables with all variable index data

lev4_statistics.csv	7/24/2025	2.81 MB
lev5_statistics.csv	7/24/2025	7.49 MB
lev6_statistics.csv	7/24/2025	16.0 MB

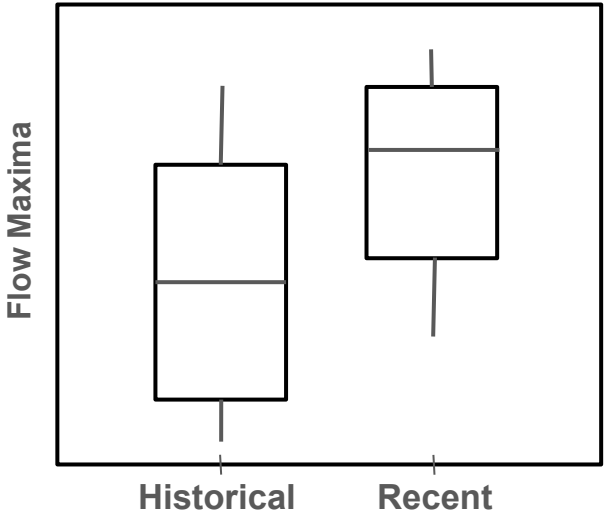
Phase 2: Interactive Maps and User Friendly Interface



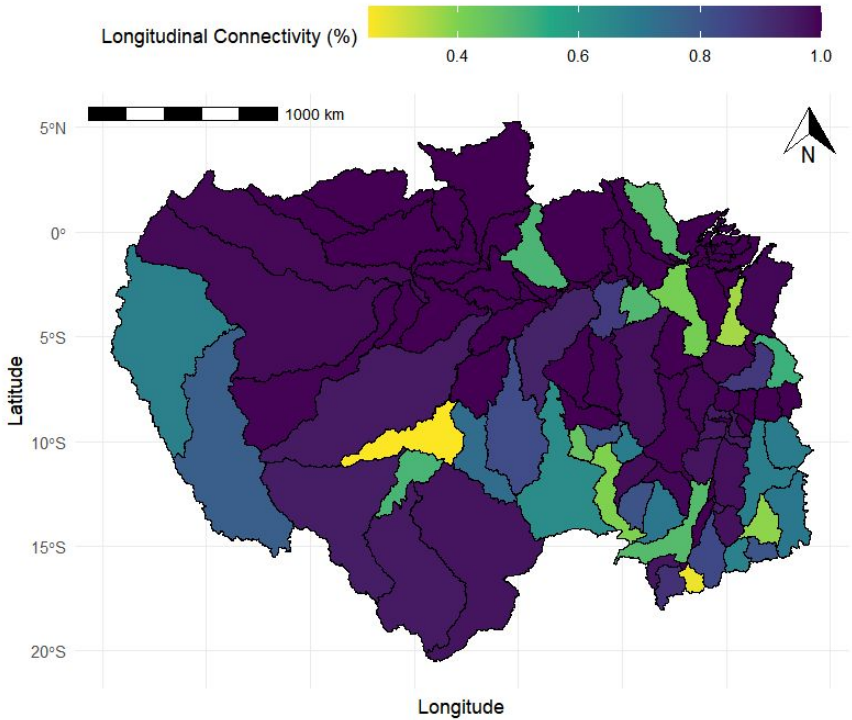
Phase 1: **Structure** – Flood Regime

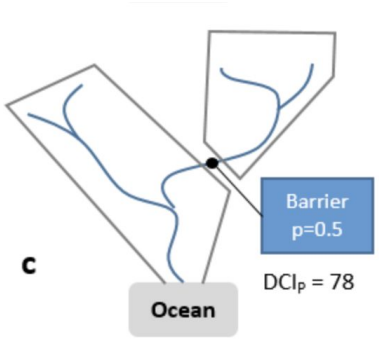


Example: Change in Flow Maxima



Phase 1: **Structure –** Longitudinal Connectivity

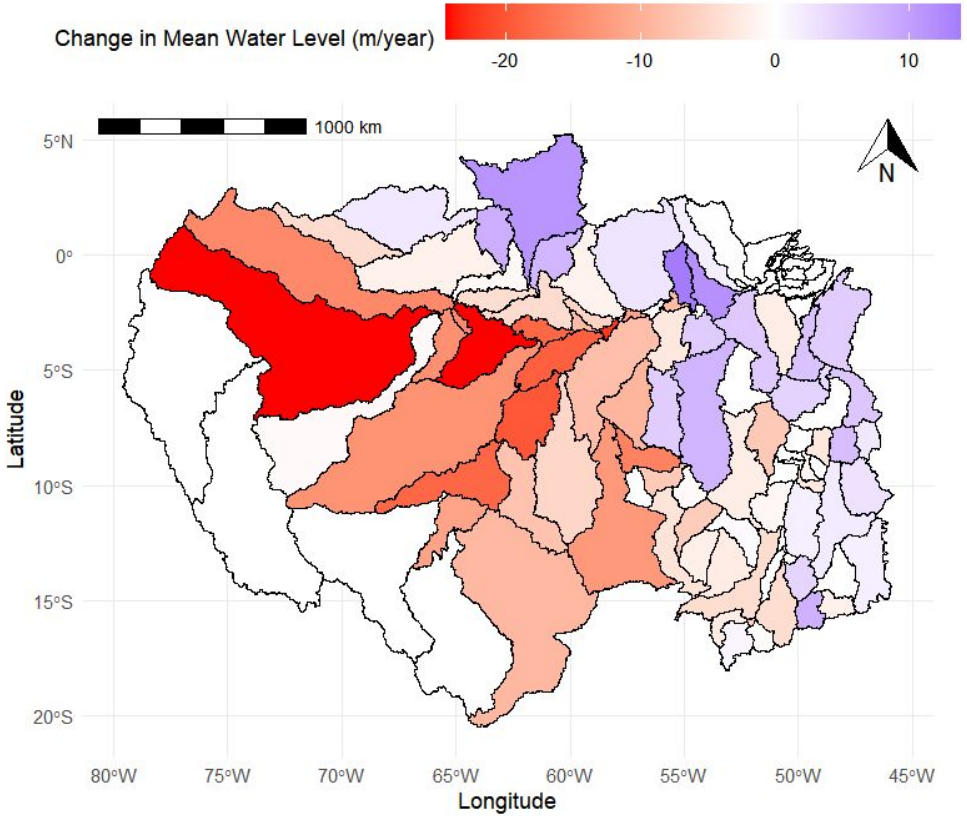




Sources: HydroRIVERS, OSM, RAISG, Heilpern et al., 2025, DDSA, Cote et al. 2008

Dendritic connectivity index measure fragmentation of the river network, operational and under construction dams

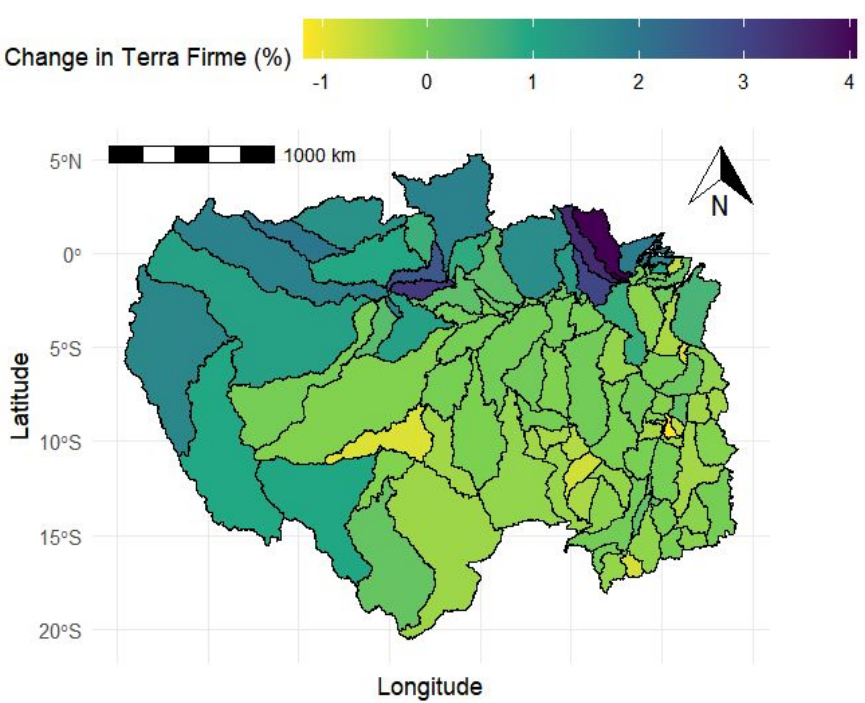
Phase 1: **Structure –** Floodplain Inundation Extent



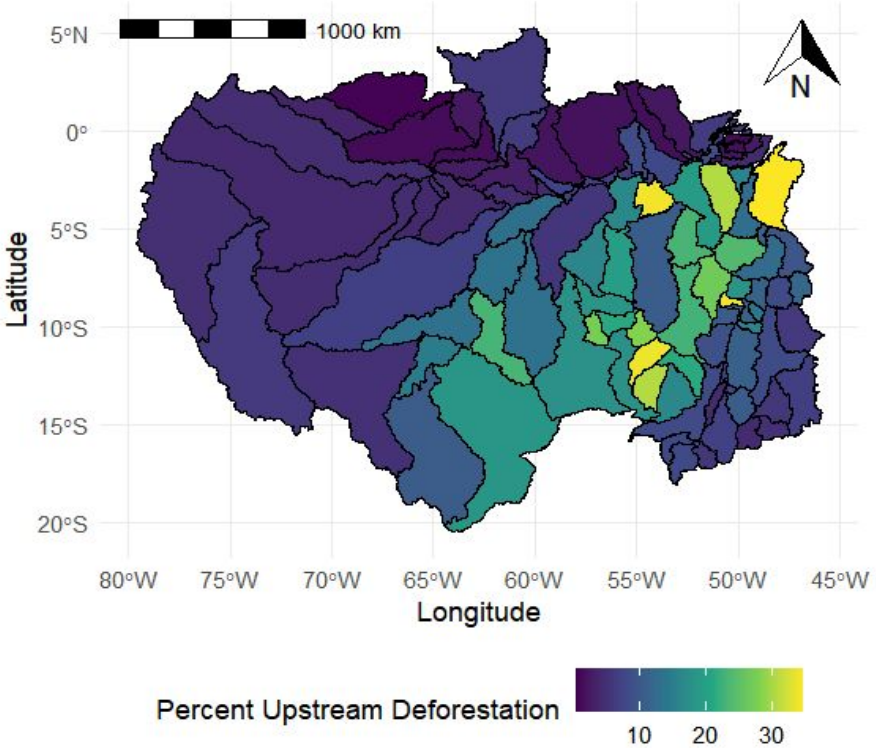
Sources: ANA Water level gauges

Periodic inundation of the floodplain conceptualized as the **deviation in water level**

Phase 1: **Function –** Upland Cover & Upstream Deforestation



Terra firme change over the years (2016-2024).
Yellow = % loss over a year
Purple = % gain over a year



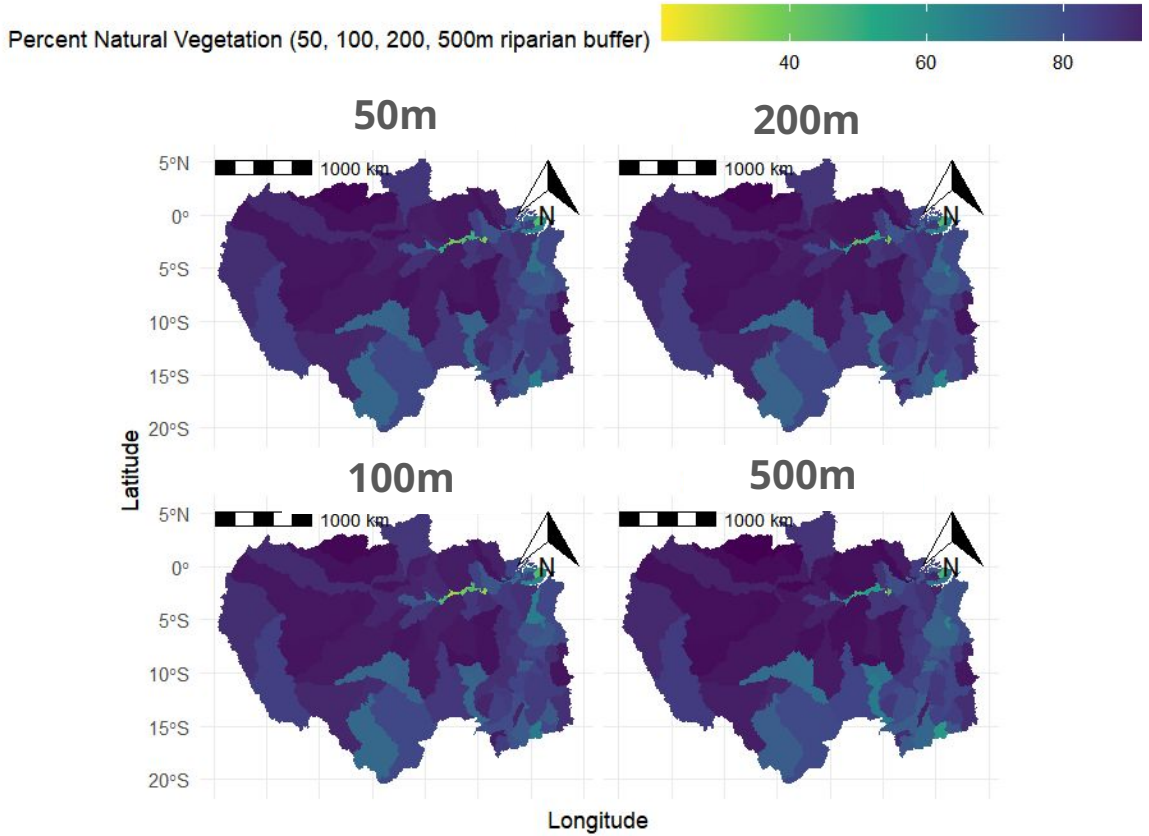
Everything that is upstream from the outlet of the selected (Source: Hansen et al., 2024)
Complements local deforestation statistics with forest loss across the basin

Phase 1: **Function** – Riparian Cover

Percent of natural vegetation within the **riparian buffer**

Natural vegetation = forest, shrub, scrub, flooded vegetation

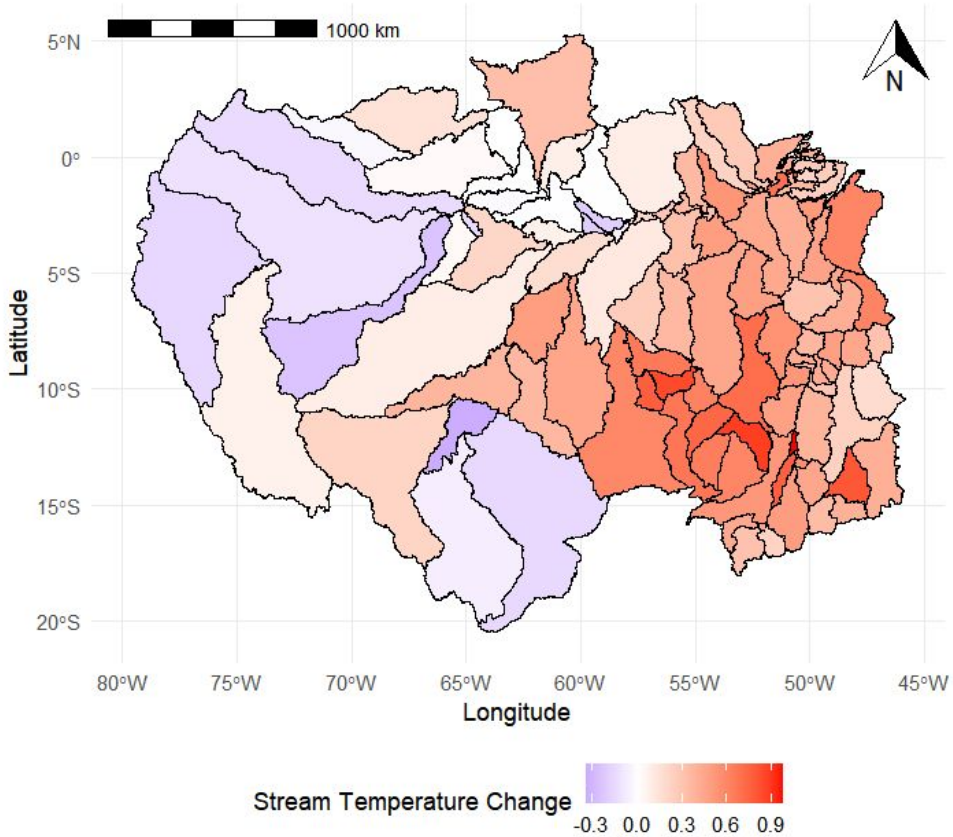
- 50-100 m for fish and amphibians
- 200-500 m relevant to birds and mammals



Generated from HydroRivers stream orders 1-8

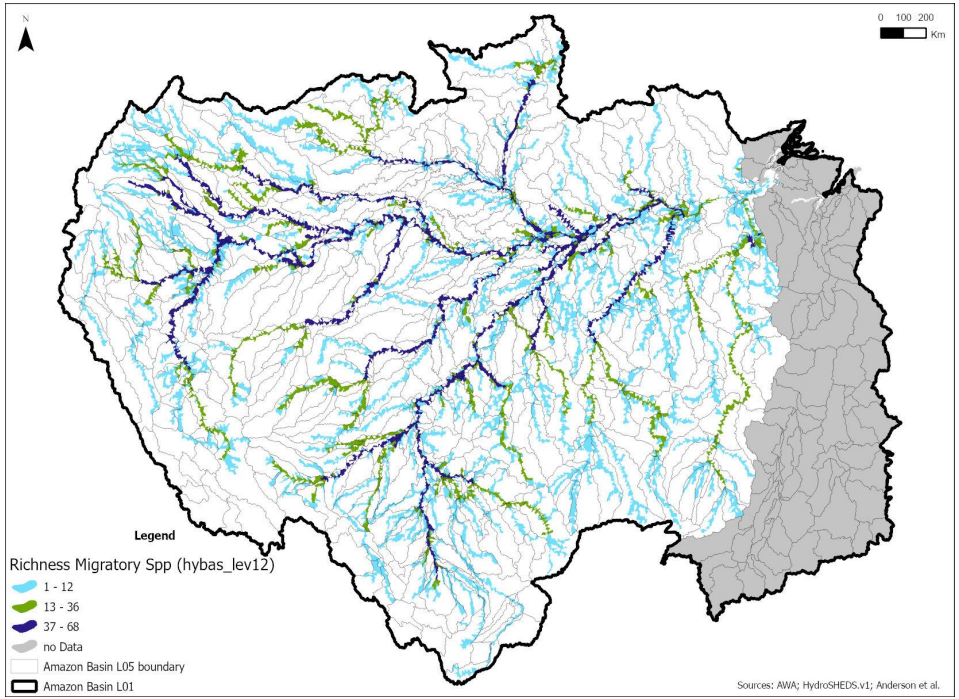
Phase 1: **Function –** Stream Temperature

Change in median dry season stream temperature from 2014 to the present

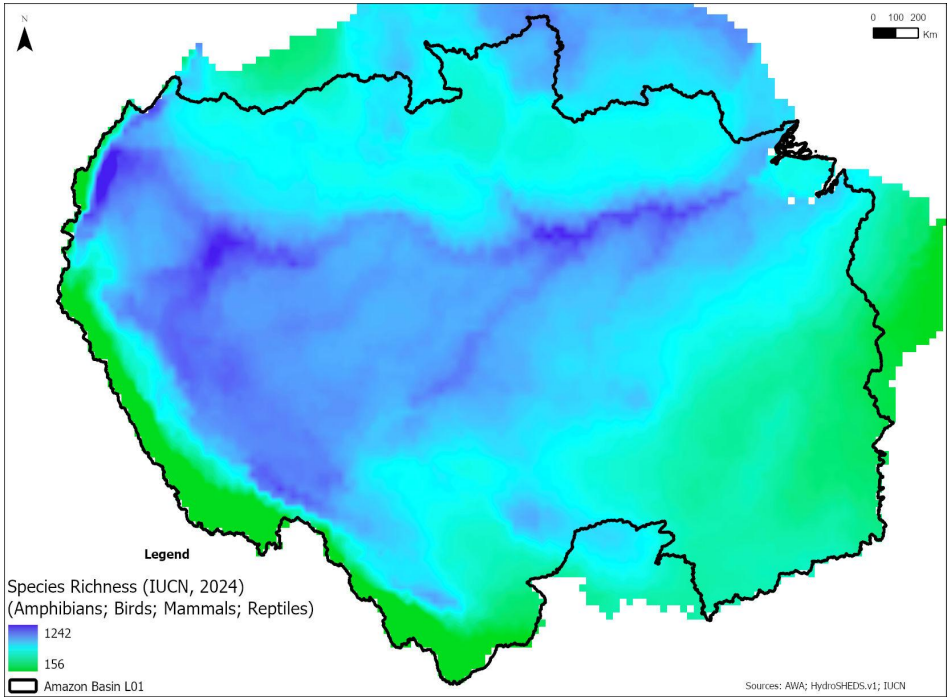


(Current Source: DynWat, Landsat LST data in process)

Phase 1: Composition – Migratory Fish and ABMR



Species Richness



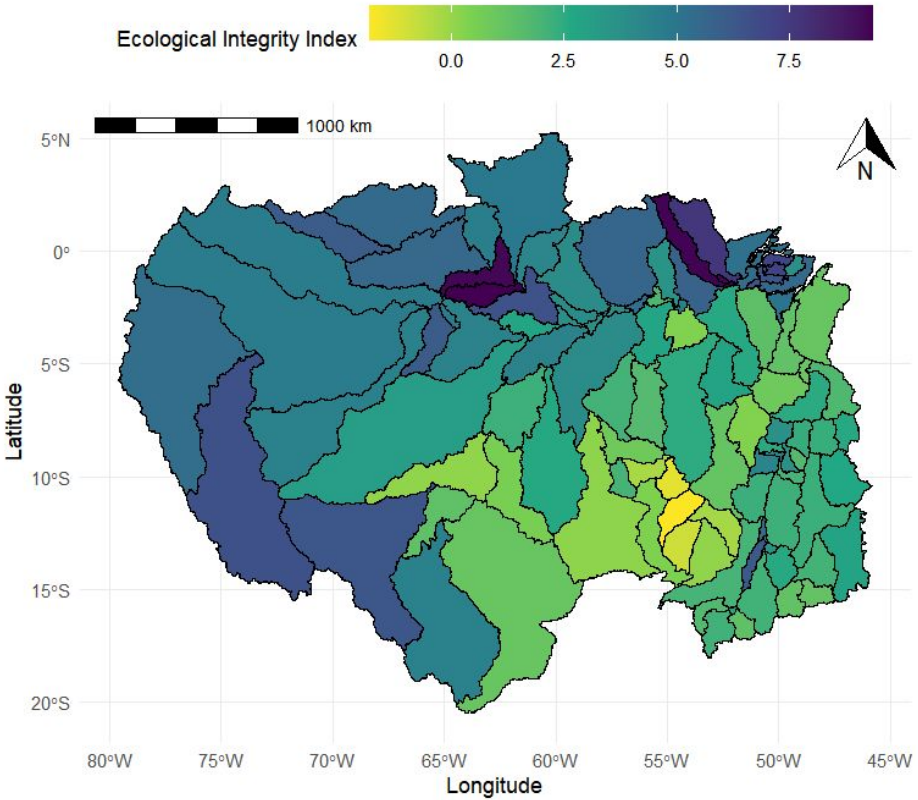
Modeled Species Richness

Sources: Anderson et al. 2025, Caldas et al. 2023 and the Global Biodiversity Information Facility (GBIF)

Source: Caldas et al. 2023

Conceptual Framework Ecological Integrity of Amazonian Freshwater Ecosystems

TEMPORAL + **SPATIAL**



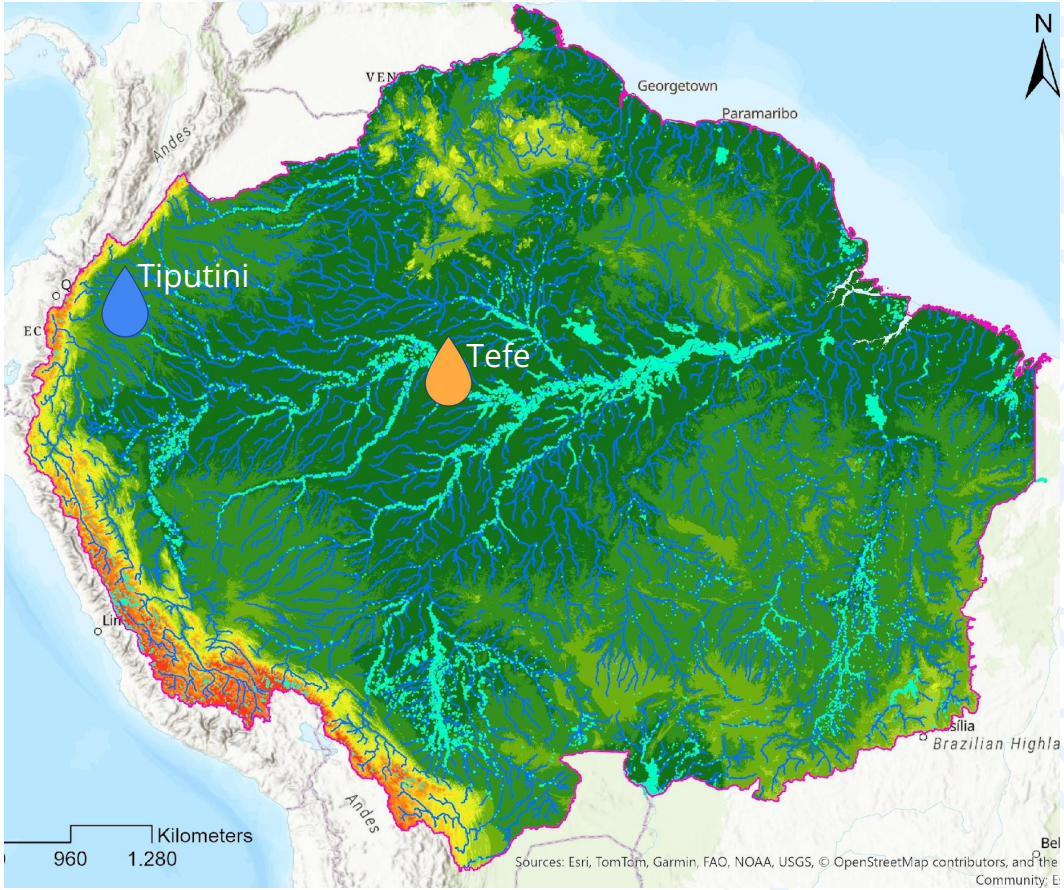
Interpretation

- **Yellow** = areas with more change in variables & deforestation
- **Blue** = areas with less change and more free flowing rivers

Next Steps

- Incorporate feedback from multiple partners
- Develop user-friendly interface

SAWA – Objetivo Específico 2



Projetar, testar em campo e concluir uma **prova de conceito para o monitoramento participativo** da água e dos ecossistemas de água doce em pelo menos duas sub-bacias importantes (Napo nos Andes e Lago Tefé nas terras baixas)

Monitoramento participativo das águas amazônicas

<u>O que queremos fazer?</u>

Desenvolver uma **estratégia sustentável e transdisciplinar** de um monitoramento participativo de **longo prazo** para **alertar problemas socioambientais** em sistemas aquáticos amazônicos, buscando soluções de forma conjunta com atores locais

Pensar um **protocolo** que possa ser aplicado em outros rios e lagos amazônicos!

Seca de 2023 no Lago Tefé: 209 botos mortos em cerca de 1 mês

- 1º caso de mortandade de mamíferos aquáticos por hipertermia no mundo
- Temperatura de mais de 40°C na água
- Ocorreu em outros lagos?

© Miguel Monteiro

© André Zumak

Comunidades isoladas

Município de Tefé em outubro de 2024: 160 comunidades ribeirinhas, 122 isoladas

LAGOS SENTINELAS DA AMAZÔNIA

Centro Transdisciplinar para Compreensão das Dinâmicas Socioambientais e das Águas Amazônicas sob Mudanças Climáticas

© André Zumak

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LAGOS SENTINELAS
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Mamirauá
1
UFAM-Coari
2
3
INPA
UFAM-Itacoatiara
4
UFOPA
5


1) Lago Tefé
Condições Normais

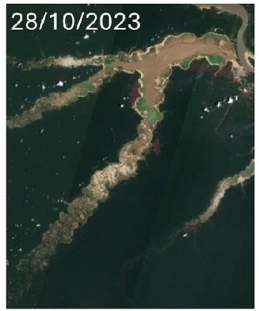

2) Lago Coari


3) Lago Janauacá


4) Lago de Serpa


5) Lago Grande de Monte Alegre


18/10/2023


28/10/2023


08/10/2023


27/10/2023


30/10/2023

O que entendemos por ‘participativo’?

- Criação de um espaço de escuta sobre percepções e necessidades socioambientais
- Criação colaborativa de protocolos de monitoramento
- Monitoramento baseado nas demandas comunitárias
- Cocriação de soluções para os desafios vigentes
- Educação e divulgação

É uma estratégia de engajamento!

Sítios pilotos

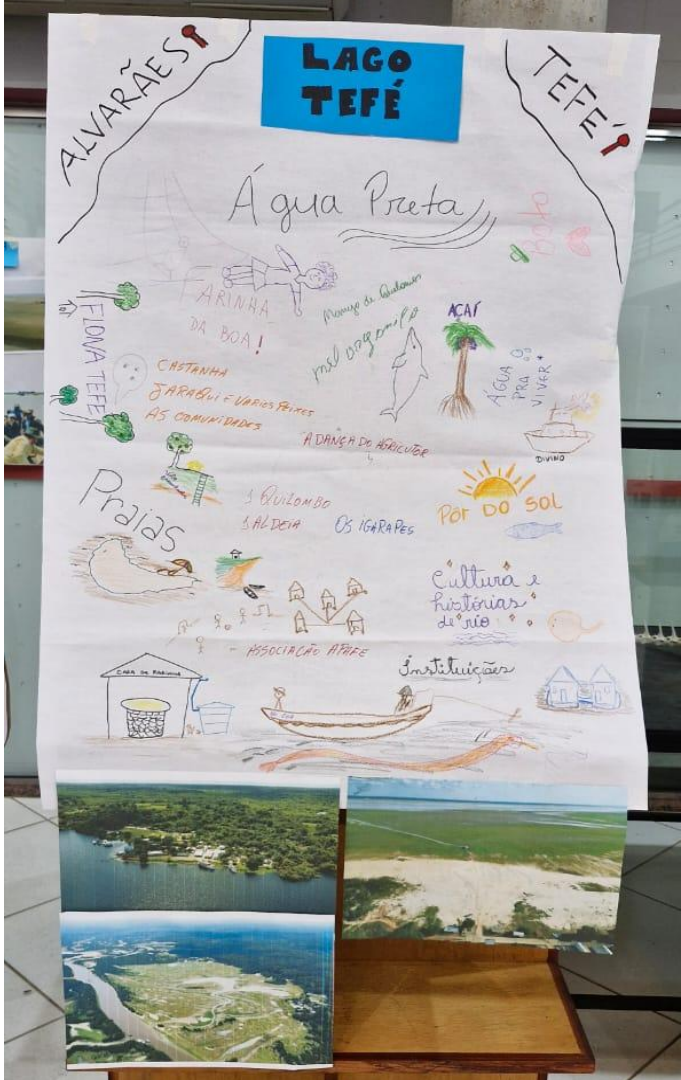
Amazônia Andina (Rio Tiputini)

https://GeoffGallice.com

Amazônia Central (Lago Tefé)

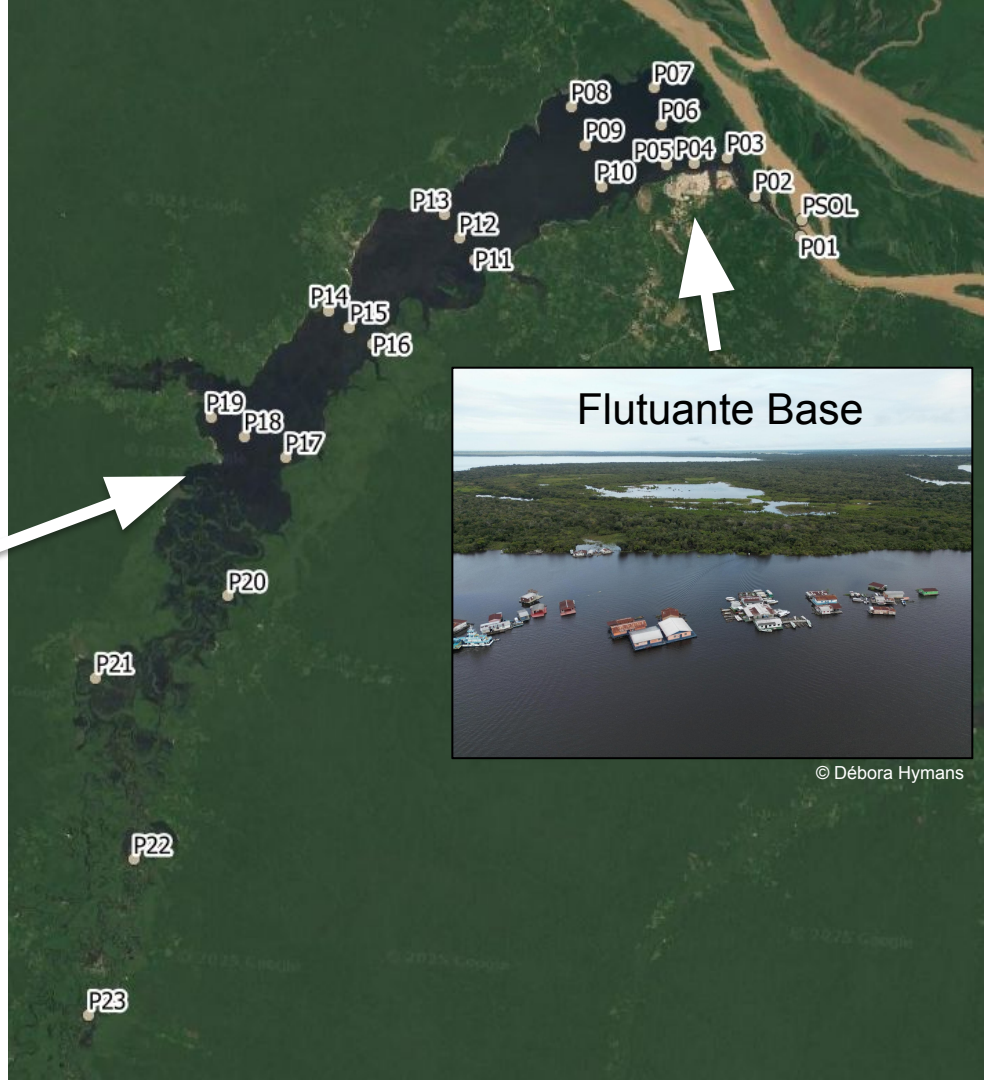
Sítio Piloto 1: Lago Tefé

Oficinas participativas



Sítio Piloto 1: Lago Tefé

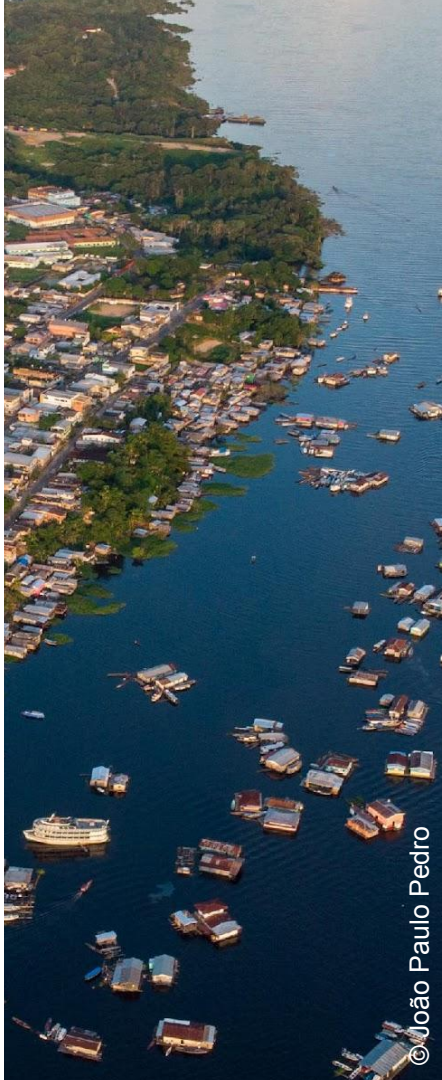
Monitoramento Ambiental



Sítio Piloto 1: Lago Tefé

Próximas Etapas

- Oficinas participativas para discussão de problemas e demandas socioambientais no Lago Tefé
- Monitoramento ambiental mensal do lago com participação comunitária
- Engajamento comunitário para monitoramento ambiental conjunto (clima, nível do lago, temperatura da água)



Sitio Piloto 2: Sistema fluvial del Río Tiputini

Ecosistemas de Aguas blancas
“Várzea” Andino - Amazónica

Esteros - aguas blancas

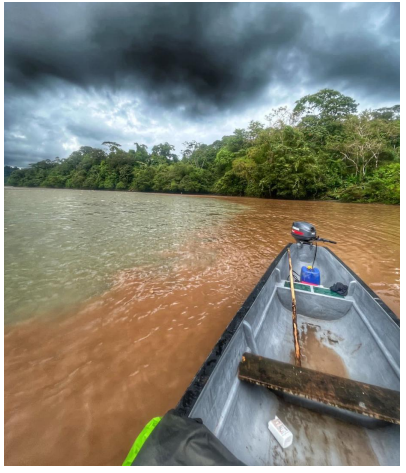
Lagos de recodo - aguas blancas

Esteros - aguas negras

Lagos de depresión - aguas negras

Sitio Piloto 2: Sistema fluvial del Río Tiputini

Prueba de campo:
ejem: Condiciones meteorológicas y nivel del agua



Sitio Piloto 2: Sistema fluvial del Río Tiputini

Prueba en campo: ejem: Nivel del agua (movilización)

Prueba de campo: ejem: Agua de consumo y recreación

Nuestro enfoque es transdisciplinario

1. Integración de saberes
2. Crear discusiones sobre cuestiones de poder
3. Contexto relacional en el que se accede y se interpreta a la información
4. Los participantes deciden el objetivo del proyecto/ toman los datos/ eligen qué hacer con ellos.

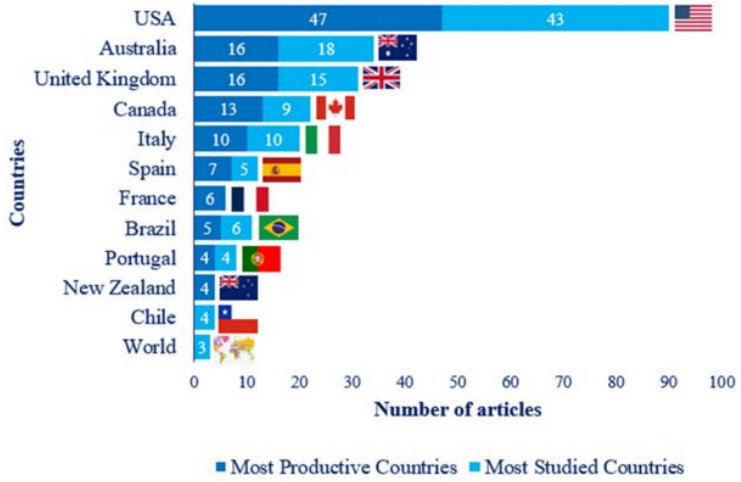


Figure 3. The geographic distribution of the 10 most productive and studied countries in citizen science in aquatic ecology. Databases used: Web of Science and Scopus (2003–2024).

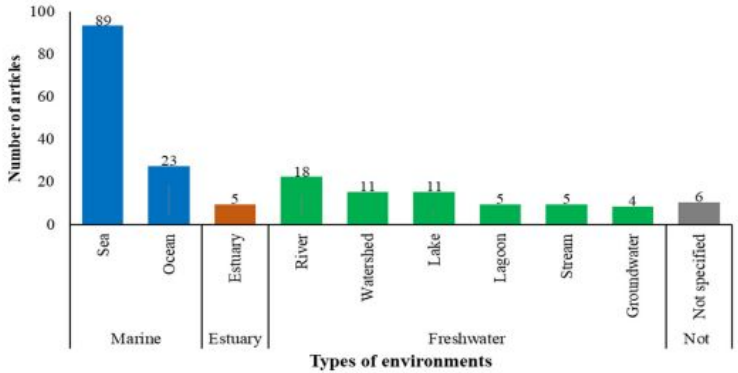


Figure 5. Types of environments where citizen science studies in aquatic ecology are conducte Databases used: Web of Science and Scopus (2003–2024).

Las iniciativas de ciencia ciudadana rara vez involucran a poblaciones con epistemologías indígenas o no occidentales.

Nina Lameira et al., 2025

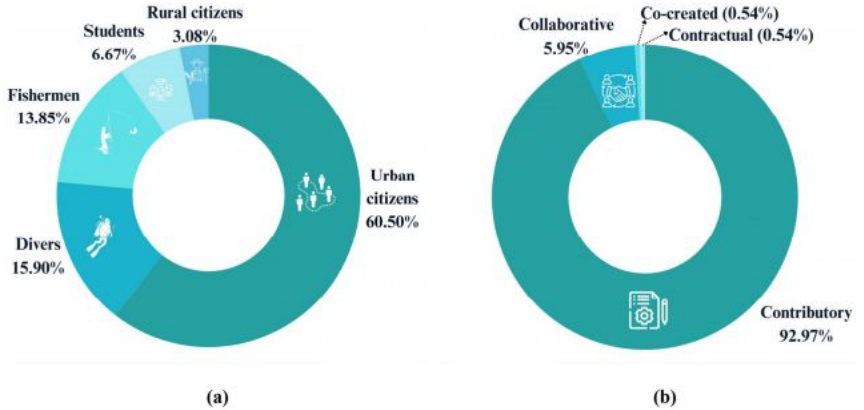


Figure 8. (a) Types of participants. (b) Levels of citizen engagement in citizen science studies in the field of aquatic ecology available in the Web of Science and Scopus databases (2003–2024).

Sitio Piloto: Andean – Amazon (Rio Tiputini)

Talleres con comunidades Waorani

Taller 1. Cual es la relación entre las personas y los ecosistemas acuáticos? Quien o que les importa?

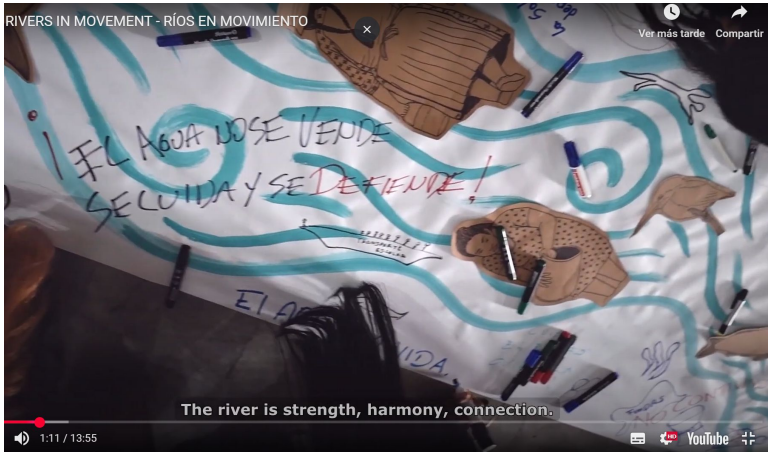
Metodo: juego de roles

Sitio Piloto: Andean – Amazon (Rio Tiputini)

Talleres con comunidades Waorani

Taller 2.

- Cómo están conectados los espacios acuáticos?
- Como esta conectada la gente?
- Hay problemas de conectividad?
- Que facilita o limita la conectividad?
- Cómo están relacionadas las comunidades (arriba/abajo)?



https://movingrivers.org/learn/#multimedia

Method: mapeo participativo

Sitio Piloto: Andean – Amazon (Rio Tiputini)

Talleres con comunidades Waorani

Taller 3.

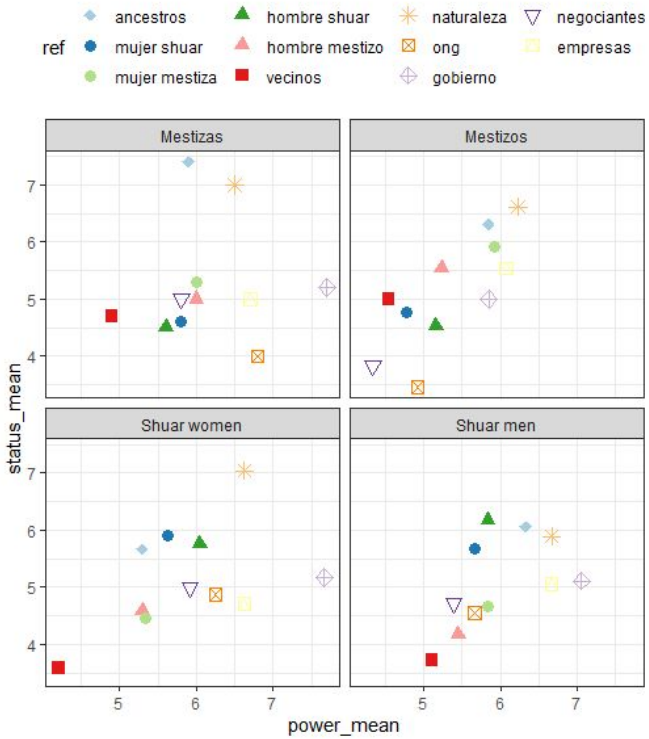
Pregunta 1: Quien influye en las decisiones sobre el agua?

Metodo: ranking de relaciones, actores influyentes

Pregunta 2: Alguna vez han registrado:

datos,
Historias,
sobre el agua, o espacios relacionados con el agua?

Qué necesitamos medir?



Rosero-Anazco et al., 2025

Apoyando a la Alianza de Aguas Amazónicas.

Resultado: **Protocolos** para el monitoreo de la **integridad ecológica** de los ecosistemas de agua dulce, que integran métodos y saberes desde un **enfoque transdisciplinario.**

Gracias!

Layers & Sources

Structure

- **Flood Regime** (Change in Magnitude, Duration, Low Flows) - ANA, INAMHI
- **Longitudinal Connectivity** - HydroRIVERS, OSM, RAISG, Heilpern, DDSA, Cote et al., 2008
- **Floodplain Inundation Extent** - in situ monitoring

Function

- **Riparian Cover** (50m, 100m, 150m, 200m) - Dynamic World
- **Vegetation Cover** - Dynamic World
- Upstream Deforestation - Dynamic World
- **Water Temperature** - Landsat LST

Composition

- **Migratory Fish Species** - Anderson et al 2025
- River Turtles - Caldas et al 2022
- Dolphins - Caldas et al 2022
- Species Richness - IUCN 2024

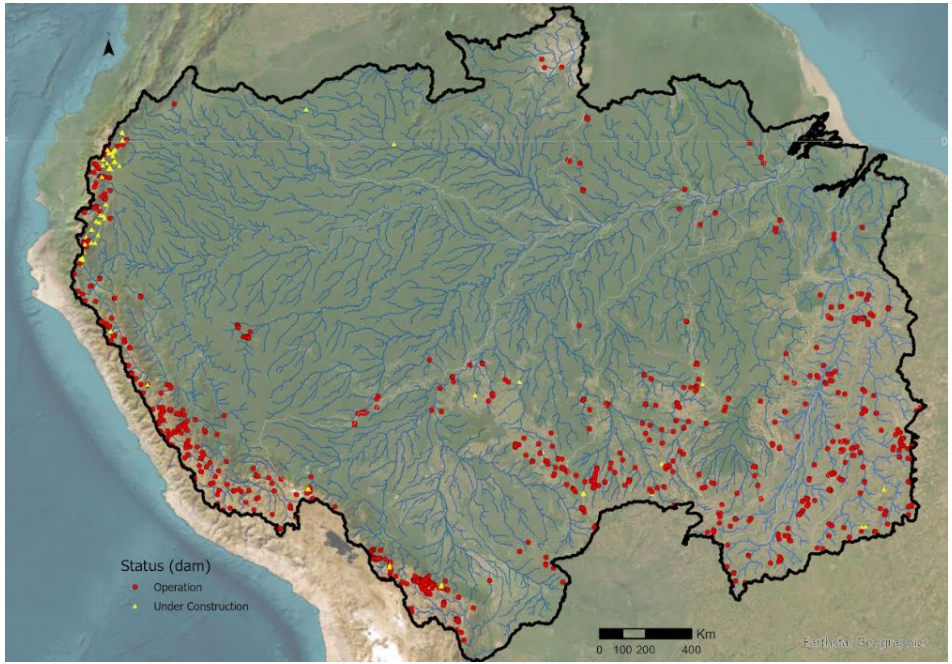
TEMPORAL

SPATIAL

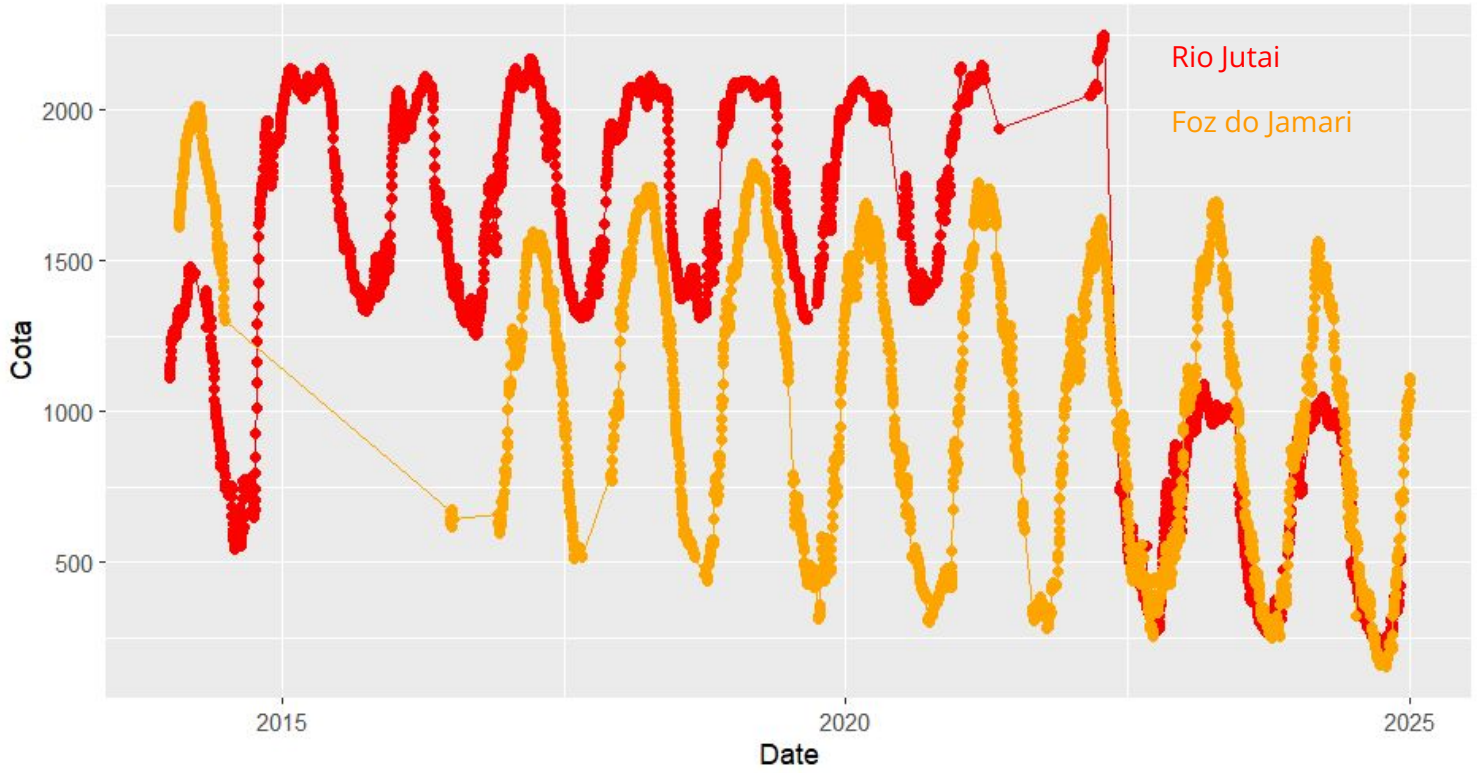
Map of Barriers (operational and under construction)

Sources:

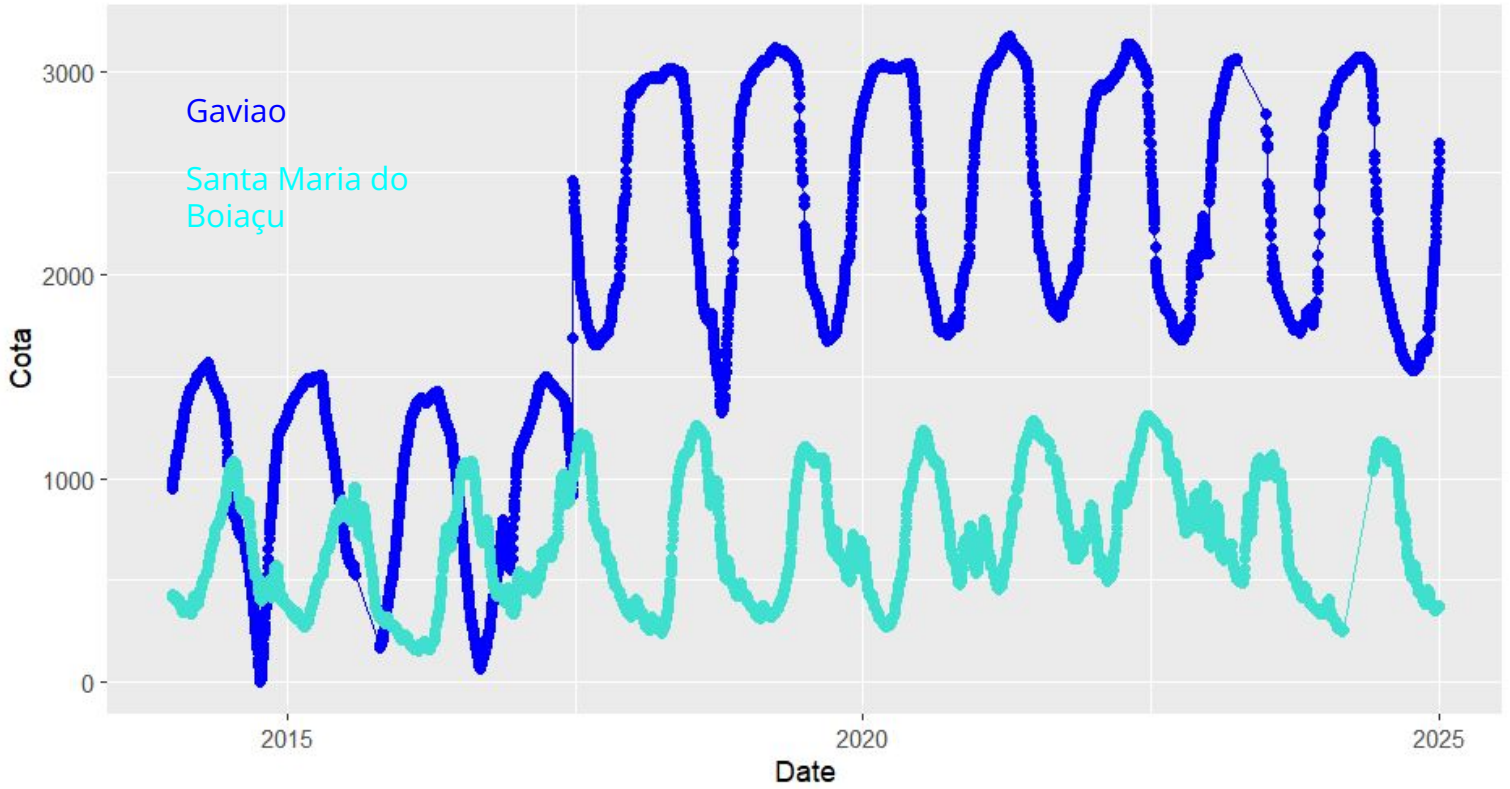
- Global Dam Watch (GDW) (HYRIV_ID match)
- Hydroelectrics under “operation” and “in construction” status from RAISG
- Dataset of Georeferenced Dams in South America (DDSA) (Paredes-Beltran, et al., 2021)
- Open Street Map (OSM) (Near distance match)
- Heilpern et al., 2025. (“operation” & “under construction” status were used) (HYRIV_ID match)



Miscellaneous: Water Level Trends

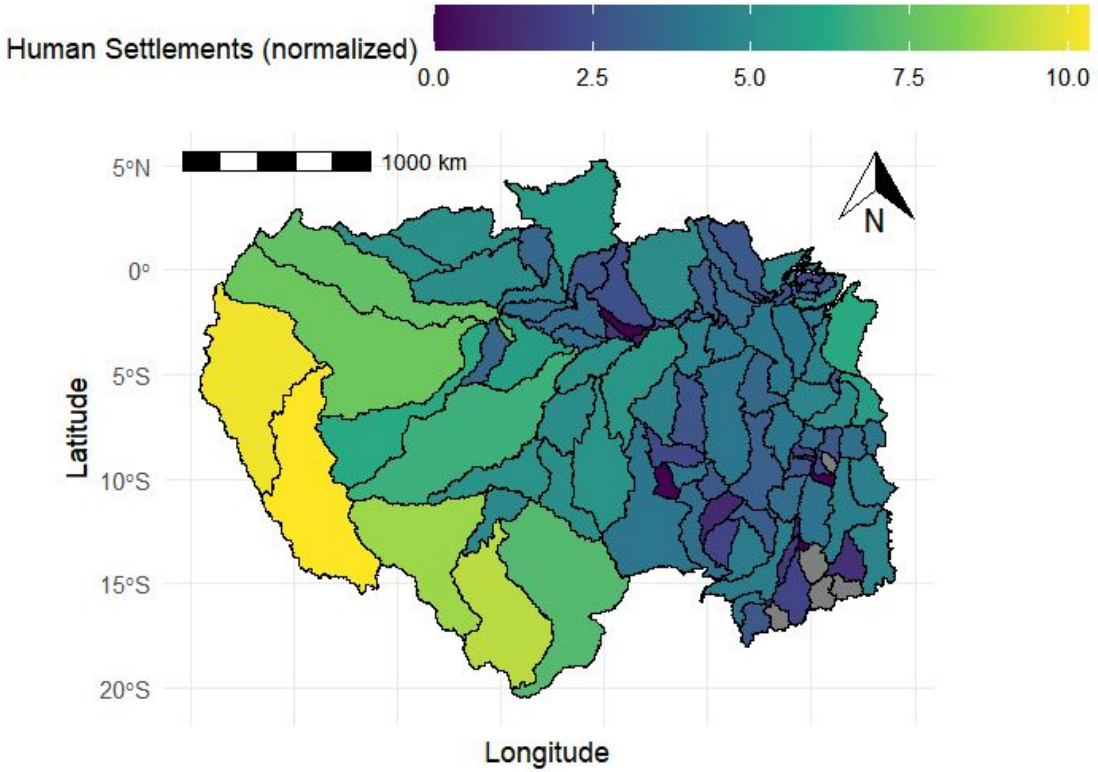


Miscellaneous: Water Level Trends

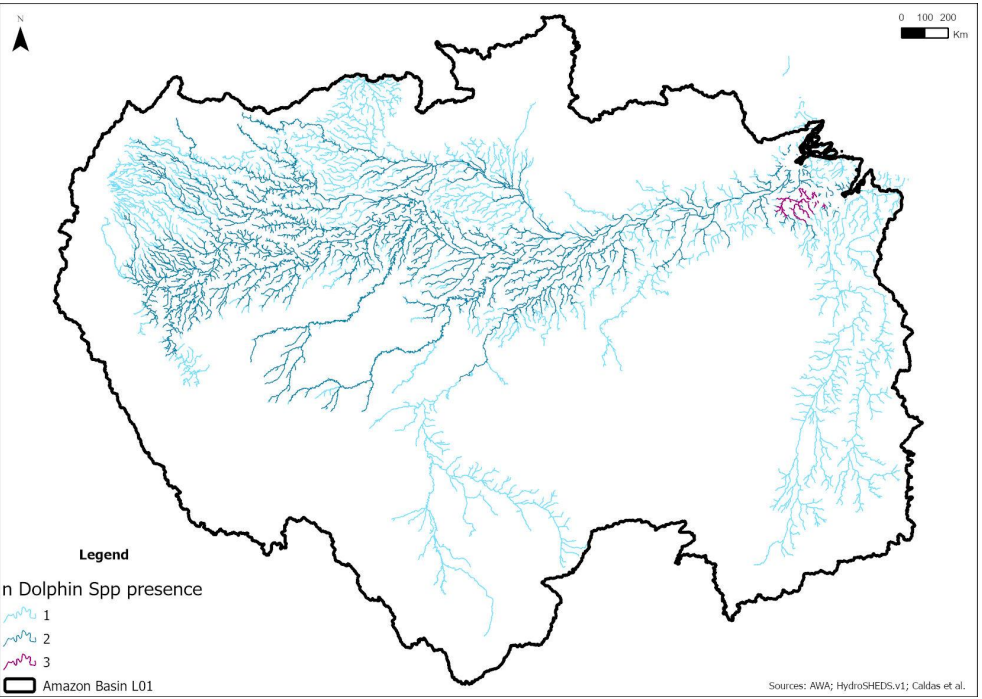


Human Settlements (OTCA)

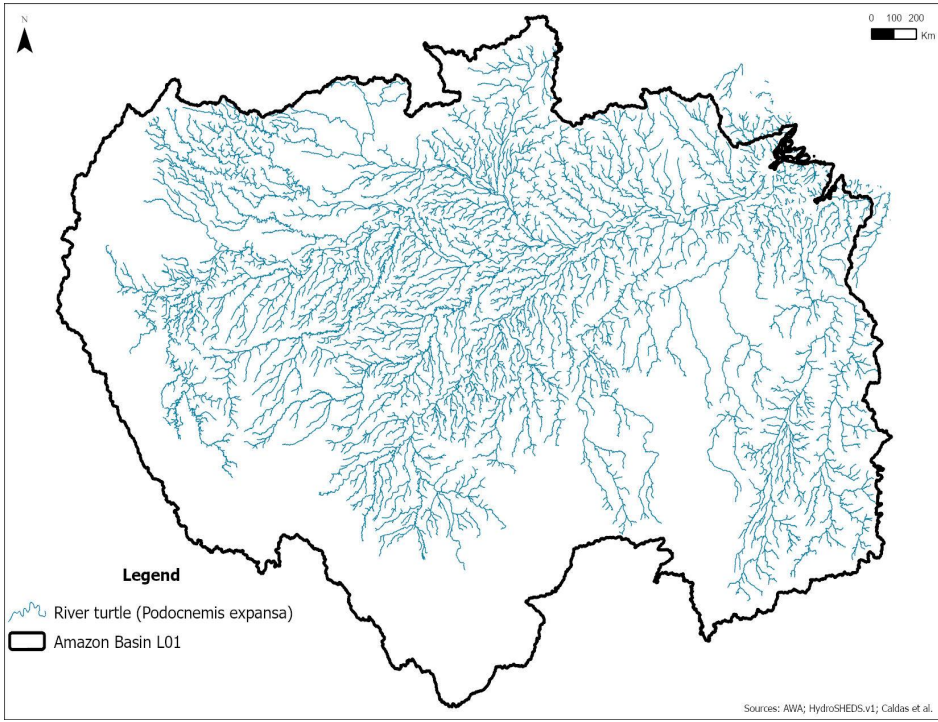
Quantified as the log of number of human settlements per basin



Phase 1: Composition – River dolphin and ABMR



Modeled Species Distribution



Species Distribution

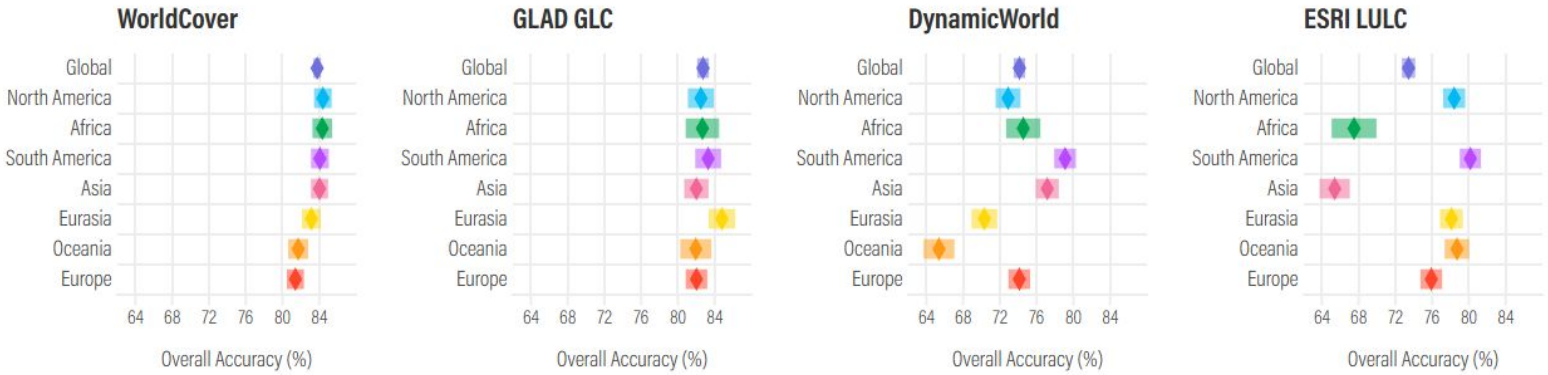
Sources: Caldas et al., 2023

Dynamic World

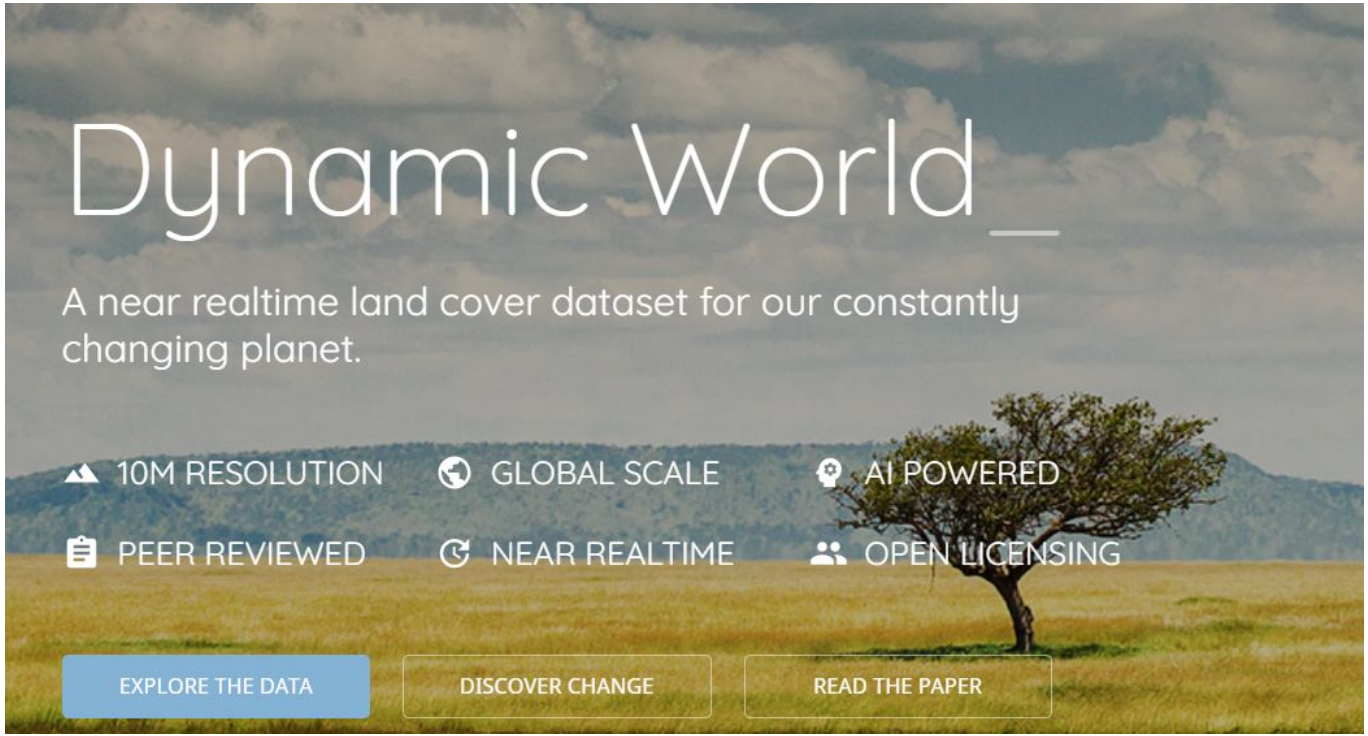
Global land cover maps compared

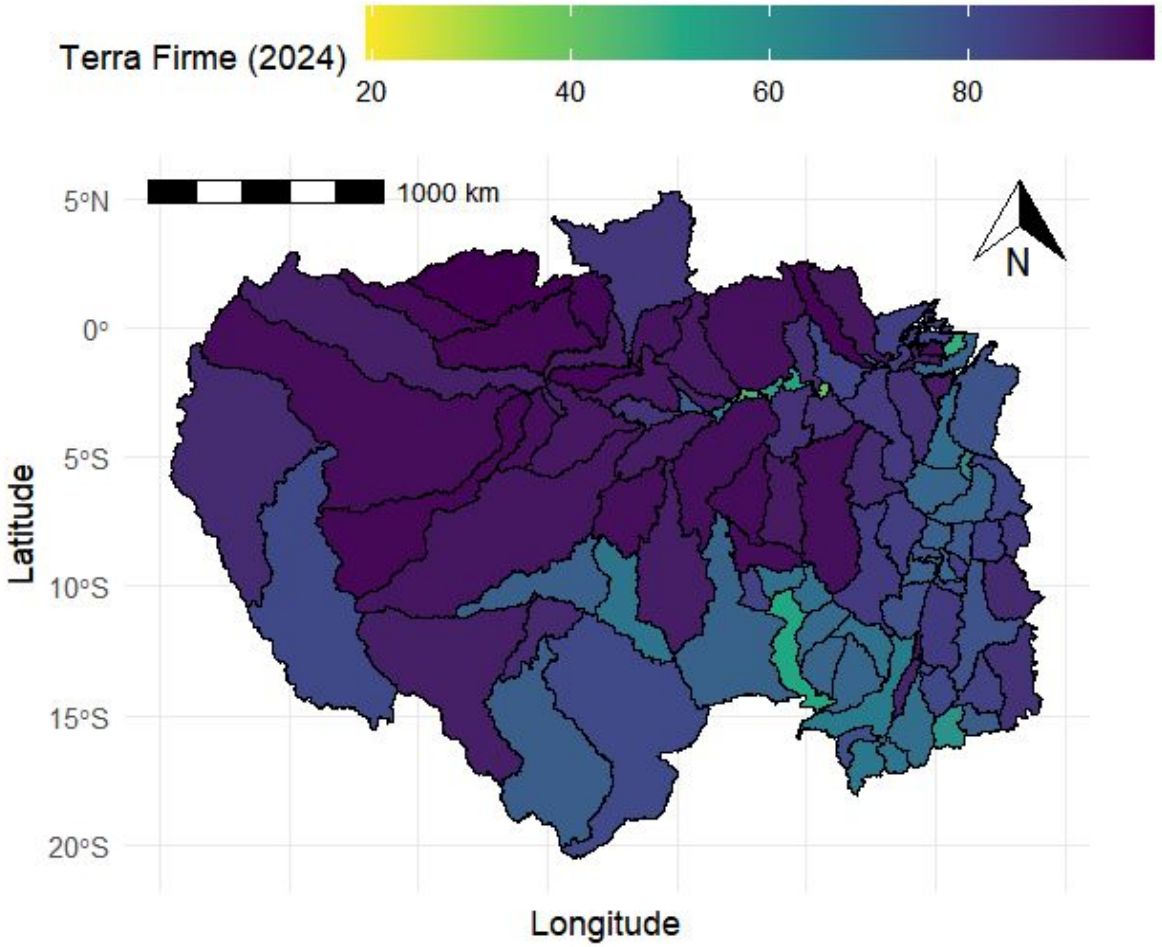
Map	Satellite imagery used	Period of data	Number of classes	Spatial resolution
WorldCover	Sentinel-1, Sentinel-2	2020, 2021	11	10 meter
Dynamic World	Sentinel-2	2015-2024	9	10 meter
ESRI LULC	Sentinel-2	2017-2023	9	10 meter
GLAD GLC	Landsat Analysis Ready Data	2000-2020	106**	30 meter

Overall accuracy of the global land cover maps by continent



Dynamic World




Terra Firme (2024)
20
40
60
80
1000 km
N
5°N
0°
5°S
10°S
15°S
20°S
Latitude
Longitude

More detail on index calculations

Ec_Int_Ind <- **- abs(flow_norm_mean) - ## change in mean flow**
abs(low_flow_days_mean) - ## change in low flow days
abs(flood_duration_days_mean) - ## change in flood duration
abs(maxima_mean) - ## change in flow maxima
abs(minima_mean) - ## change in flow minima
abs(wlSlope) + ## change in water level
DCI_lev05f + ## how free flowing it is
norm_rip50 + ## amount of natural veg
norm_rip100 + lev5_stats$norm_rip200 + lev5_stats$norm_rip500 +
slopeTerraFirme - ## change in terra firme
perLoss_Up_norm + ## upstream deforestation
norm_num_species + ## migratory fish
norm_dolphin + ## dolphins
norm_turtle + ## turtles
norm_iucn ## iucn