Supplementary Information

"Severe droughts reduce river navigability and isolate communities in the Brazilian Amazon"

Authors

Letícia Santos de Lima[1,2] (corresponding author)
ORCID: 0000-0002-0268-2055 leticia.lima@uab.cat

Francisco Eustáquio Silva[3,2]
ORCID: 0000-0003-4304-8998

Paula Rosana Dorio Anastácio[4]
ORCID: 0009-0007-8989-3085

Marina Marcela de Paula Kolanski[4]
ORCID: 0009-0003-0400-5693

Ana Carolina Pires Pereira[5]
ORCID: 0009-0002-1598-6776

Marianne S. R. Menezes[4]
ORCID: 0009-0006-2359-312X

Evandro Landulfo Teixeira Paradela Cunha[6]
ORCID: 0000-0002-5302-2946

Marcia Nunes Macedo[7,8]
ORCID: 0000-0001-8102-5901

Affiliations

[1]Institut de Tecnologia i Ciencias Ambientals (ICTA-UAB)
Universitat Autònoma de Barcelona Cerdanyolla del Vallès, Catalunya, Spain
[2]Programa de Pós-graduação em Saneamento, Meio Ambiente e Recursos Hídricos (SMARH),
Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil
[3]Hydraulic Engineering & Water Resources Department
Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil
[4]Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil
[5]Espace-DEV
IRD, Univ. Montpellier, Univ. Guyane, Univ. Reunion, Montpellier, France
[6]Faculty of Letters
Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil
[7]Woodwell Climate Research Center, Falmouth, MA, United States
[8]Instituto de Pesquisa Ambiental da Amazônia, Brasília, DF, Brazil

Data availability statement

The data that support the findings are publicly available in "CORA.Repositori de Dades de Recerca" at https://doi.org/10.34810/data1390. These data include water level records, a data summary of river gauging stations, the list of media articles and selected statements as well as their corresponding sources. All data used in this scientific study were derived from contents that were free-of-charge at the time of their collection (either from governmental official sources, publications and articles without paywall, or from non-profit organizations). Data sources are available in the links provided in Supplementary Table 1 in this document, and Supplementary Data 1 (via repository).

Code availability statement

The R codes used to process the hydrological data in this paper are available in "CORA.Repositori de Dades de Recerca" at https://doi.org/10.34810/data1390.

List of materials:

- Supplementary Table 1: Spatial datasets used in this study and respective sources.
- Supplementary Note 1: Shortest distance from non-Indigenous localities to water bodies & all roads.
- Supplementary Table 2: Histograms for nearest distance (km) between non-Indigenous localities (IBGE 2021) and (A) Maximum, and (B) Minimum Inundation Area Map (Fleischmann et al. 2022).
- Supplementary Table 3: Nearest distance between non-Indigenous localities and inundation area - Descriptive metrics.
- Supplementary Table 4: Histograms for nearest distance (km) between non-Indigenous localities (IBGE 2021) and roads.
- Supplementary Table 5: Nearest distance between non-Indigenous localities and roads - Descriptive metrics (km).
- Supplementary Table 6: Matrix of shortest distances (km), comparing distance ranges from non-Indigenous localities (number and % in relation to total) to roads [line] and water bodies [column] (maximum inundation map).
- Supplementary Table 7: Matrix of shortest distances (km), comparing distance ranges from non-Indigenous localities (number and % in relation to total) to roads [line] and water bodies [column] (minimum inundation map).
- Supplementary Table 8: Nearest distance between Indigenous villages and inundation area - Descriptive metrics.
- Supplementary Table 9: Histograms for nearest distance between Indigenous villages (FUNAI 2020) and (A) Maximum, and (B) Minimum Agreement Inundation Map (Fleischmann et al. 2022).
- Supplementary Table 10: Histograms for nearest distance between Indigenous villages (FUNAI 2020) and roads.
- Supplementary Table 11: Nearest distance between Indigenous villages and roads - Descriptive metrics.
- Supplementary Table 12: Matrix of shortest distances (km), comparing distance ranges from Indigenous villages (number and % in relation to total) to roads [line] and water bodies [column] (maximum inundation map).

- Supplementary Table 13: Matrix of shortest distances (km), comparing distance ranges from Indigenous villages (number and % in relation to total) to roads [line] and water bodies [column] (minimum inundation map).
- Supplementary Figure 1: Amazon maximum inundation extent map (Fleischmann et al. 2022), overlayed by the combined map of roads, including paved and unpaved ones (CSR 2016, IMAZON 2012, SNV 2020). Red dots represent Indigenous villages of the Brazilian portion of the basin (FUNAI 2020). Pink dots represent non-Indigenous localities (remote rural settlements, villages & cities of the Brazilian portion of the basin, IBGE 2021). Brazilian Amazon States are identified by their abbreviation: AC (Acre); AM (Amazonas); AP (Amapá); MT (Mato Grosso); PA (Pará); RO (Rondônia); RR (Roraima).
- Supplementary Note 2: Distribution of river gauging stations
- Supplementary Figure 2: Spatial distribution of selected river gauges in the Brazilian portion of the Amazon basin. Brazilian Amazon States are identified by their abbreviation: AC (Acre); AM (Amazonas); AP (Amapá); MT (Mato Grosso); PA (Pará); RO (Rondônia); RR (Roraima).

Supplementary Table 1: Spatial datasets used in this study and respective sources

Theme	**Feature type**	**Source**	**Year**
Political boundaries https://www.ibge.gov.br/geociencias/organizacao-do-territorio/malhas-territoriais/15774-malhas.html	vector / polygon	IBGE (*Brazilian Institute of Geography and Statistics*) Collection: "Malhas Territoriais"	2018
Amazon Basin limits ("Nível 1") https://metadados.snirh.gov.br/geonetwork/srv/api/records/0c698205-6b59-48dc-8b5e-a58a5dfcc989	vector / polygon	ANA (*National Agency of Water and Sanitation*) Collection: "Bacias Ottocodificadas" > "Nível 1"	2017
Indigenous villages ("Aldeias") https://www.gov.br/funai/pt-br/atuacao/terras-indigenas/geoprocessamento-e-mapas	vector / point	FUNAI (*National Foundation of Indigenous Peoples*) Collection: "Aldeias"	2020
Non-Indigenous Localities: Rural remote settlements https://www.ibge.gov.br/geociencias/cartas-e-mapas/bases-cartograficas-continuas/15759-brasil.html?=&t=downloads	vector / point	IBGE Collection: "Base Cartográfica Contínua 1:250.000" > "Localidades" > "Aglomerado Rural Isolado"	2021

Non-Indigenous Localities: Villages & cities https://www.ibge.gov.br/geociencias/cartas-e-mapas/bases-cartograficas-continuas/15759-brasil.html?=&t=downloads	vector / point	IBGE Collection: "Base Cartográfica Contínua 1:250.000" > "Localidades" > "Cidades" e "Vilas"	2021
River gauging stations https://metadados.snirh.gov.br/files/f85dbf06-a869-414c-afc5-bb01869e9156/Estacoes_Fluviometricas_e_Pluviometricas_da_Rede.gpkg	vector / point	ANA Collection: "Rede Hidrometeorológica Nacional" > "Estaçoes Fluviométricas"	2022
Inundation map - max extent https://amazon-inundation.herokuapp.com	raster	Fleischmann et al.	2022
Inundation map - min extent https://amazon-inundation.herokuapp.com	raster	Fleischmann et al.	2022
Hydrography https://www.hydrosheds.org/products/hydrorivers	Vector / line	Lehner & Grill (*HydroSHEDs* database)	2013
Hydrography - major water bodies http://terrabrasilis.dpi.inpe.br/download/dataset/legal-amz-prodes/vector/hydrography.zip	vector / polygon	INPE (*National Institute for Spatial Research*)	2022
Paved and unpaved roads https://maps.csr.ufmg.br/geodownload/?workspace=CSR&store=shp__infraestrutura__panamazonia__estradas_vicinais_pan_csr__estradas_vicinais_pan	vector / line	CSR/UFMG (*Remote Sensing Center, Federal University of Minas Gerais*)	2016
Paved and unpaved roads ("Estradas oficiais e Estradas não oficiais") https://www.imazongeo.org.br/	vector / line	IMAZON (*Institute of the Amazon's Human and Environment*)	2012
Official roads (SNV) https://www.gov.br/dnit/pt-br/assuntos/atlas-e-mapas/pnv-e-snv	vector / line	SNV (*National System of Transport*)	2020

Supplementary Note 1: Shortest distance from human settlements to water bodies & roads

There is not a perfect way of calculating distances from villages and settlements to rivers and other water bodies in the Amazon basin. The reason is that every dataset available to represent water bodies as vector lines or surfaces (either as vector polygon, or raster cells) will present specific shortcomings for the task. We executed trials using HydroSHEDs[1] rivers (vector lines derived from accumulated flow maps), the official hydrography dataset from the National Water Agency of Brazil - ANA (rivers as lines digitized from remote sensing maps)[2], the water surface map from the same agency (larger water surfaces represented as vector polygons), the water surface map from the National Space Institute - INPE[3] (water surface represented as raster cells). Shortcomings were of all sorts: scale issues not allowing smaller rivers to be represented, datasets representing rivers as lines not allowing for a real estimate of distance of villages from river margins, etc. Therefore, for this article we opted for the dataset from Fleischmann et al. (2022)[4] that presents the Amazon inundation area map through an intercomparison of 18 basin-scale datasets (see related publication for details). This intercomparison includes datasets derived from radar imagery which allows the detection of flooded areas even under canopy cover, something that optical sensors (such as Landsat) are not able to do. It also includes datasets from hydrological modelling. In this study, we use two of their maps that present the agreement among datasets on a 1 km spatial resolution: (A) The maximum inundation area, which represents the surface that is interpreted as inundated during high water season; (B) The minimum inundation area, which represents the surface that is interpreted as inundated during low water season. Pixel value in those maps refer to the number of datasets in agreement regarding the classification. After visual inspection, we decided that an agreement of at least 2 datasets for A and 1 dataset for B would suffice for the aims of this work. We extracted the central point of each pixel of the two raster maps (A and B). We then used the function *v.distance* from GRASS available in QGIS, version 3.28 (https://www.qgis.org/), in order to calculate the shortest distance (straight line) between each point representing villages, settlements or municipal seats and the nearest central point of a pixel derived from the two inundation area maps.

However, 101 points representing villages or settlements fell outside of the limits of the inundation area raster map. For these points, the procedure to calculate nearest distance to water bodies was different. We merged two datasets: rivers from HydroRIVERS[5], and water surface from INPE (2021)[3], after converting the latter one into a line vector map. After that, we used the same *v.distance* tool to calculate the nearest distance to water bodies. We are aware that, for these points, by proceeding this way, it is not possible to differentiate low- and high-water seasons. However, this was found to be the only solution available to incorporate those points into the analysis.

Supplementary Table 2: Histograms for nearest distance (km) between non-Indigenous localities (IBGE 2021) and (A) **Maximum,** and (B) **Minimum** Inundation Area Map (Fleischmann et al. 2022). The table presents the number of localities that falls within a certain distance range:

(A)

interval	range [km]	abs number	freq rel	freq acum
1	0 - 5	3259	0.8877690003	0.8877690
2	5 - 10	258	0.0702805775	0.9580496
3	10 - 15	105	0.0286025606	0.9866521
4	15 - 20	29	0.0078997548	0.9945519
5	20 - 25	11	0.0029964587	0.9975484
6	25 - 30	5	0.0013620267	0.9989104
7	30 - 35	1	0.0002724053	0.9991828
8	35 - 40	2	0.0005448107	0.9997276
9	40 - 45	0	0.0000000000	0.9997276
10	45 - 50	0	0.0000000000	0.9997276
11	50 - 55	0	0.0000000000	0.9997276
12	55 - 60	0	0.0000000000	0.9997276
13	60 - 65	1	0.0002724053	1

(B)

interval	range [km]	abs number	freq rel	freq acum
1	0 - 5	3094	0.8428221193	0.8428221
2	5 - 10	251	0.0683737401	0.9111959
3	10 - 15	140	0.0381367475	0.9493326
4	15 - 20	96	0.0261509126	0.9754835
5	20 - 25	42	0.0114410242	0.9869245
6	25 - 30	34	0.0092617815	0.9961863
7	30 - 35	7	0.0019068374	0.9980932
8	35 - 40	3	0.0008172160	0.9989104
9	40 - 45	1	0.0002724053	0.9991828
10	45 - 50	2	0.0005448107	0.9997276
11	50 - 55	0	0.0000000000	0.9997276
12	55 - 60	0	0.0000000000	0.9997276
13	60 - 65	1	0.0002724053	1

Supplementary Table 3: Nearest distance between non-Indigenous localities and **inundation** area - Descriptive metrics:

(A) Nearest distance between non-Indigenous localities and **maximum** inundation area [km]:						
Min	1st Q	Median	Mean	3rd Q	Max	StDev
0.00095	0.31041	0.43884	1.72852	0.78149	64.86186	3.608737
(B) Nearest distance between non-Indigenous localities and **minimum** inundation area [km]:						
Min	1st Q	Median	Mean	3rd Q	Max	StDev
0.00095	0.33596	0.49369	2.63746	1.16393	64.86186	5.454663

We then proceeded to calculate the shortest distance between localities and roads. For that, we first merged three datasets of roads for the Amazon: IMAZON (2012)[6], CSR (2016)[7], and SNV (2020)[8]. The reason for merging lies in the fact that there is not a single reliable updated and detailed map of roads (paved and unpaved) for the Amazon, particularly when it comes to the representation of unpaved roads. Still, some of these datasets are not updated for more than 5 years (IMAZON and CSR), while the other only presents official roads (SNV 2020).

Supplementary Table 4: Histograms for nearest distance (km) between non-Indigenous localities (IBGE 2021)[9] and **roads**.

interval	range [km]	abs number	freq rel	freq acum
1	0 - 16	2342	0.6379733043	0.6379733
2	16 - 32	474	0.1291201308	0.7670934
3	32 - 48	341	0.0928902206	0.8599837
4	48 - 64	241	0.0656496867	0.9256333
5	64 - 80	140	0.0381367475	0.9637701
6	80 - 96	72	0.0196131844	0.9833833
7	96 - 112	37	0.0100789975	0.9934623
8	112 - 128	6	0.0016344320	0.9950967
9	128 - 144	3	0.0008172160	0.9959139
10	144 - 160	3	0.0008172160	0.9967311
11	160 - 176	5	0.0013620267	0.9980932
12	176 - 192	5	0.0013620267	0.9994552
13	192 - 209	2	0.0005448107	1

Supplementary Table 5: Nearest distance between non-Indigenous localities and **roads** - Descriptive metrics (km):

Min	1st Q	Median	Mean	3rd Q	Max	StDev
0.00003	0.18985	5.94690	18.63680	28.96174	208.06698	26.52825

Supplementary Table 6: Matrix of shortest distances (km), comparing distance ranges from non-Indigenous localities (total number of localities and % in relation to total) to roads [line] and water bodies [column] (**maximum inundation** map):

Water bodies, high waters (km) / Roads (km)	[0, 1]	]1, 5]	]5,10]	]10, 15]	]15, 20]	]20, …[	Total
[0, 1]	691 (18.8)	359 (9.8)	236 (6.4)	93 (2.5)	21 (0.6)	11 (0.3)	1411 (38.4)
]1, 5]	345 (9.4)	14 (0.4)	6 (0.2)	2 (0.1)	0	1 (0.0)	368 (10.0)
]5,10]	274 (7.5)	6 (0.2)	3 (0.1)	2 (0.1)	0	0	285 (7.8)
]10, 15]	234 (6.4)	6 (0.2)	2 (0.1)	1 (0.0)	0	0	243 (6.6)
]15,20]	181 (4.9)	5 (0.1)	1 (0.0)	1 (0.0)	2 (0.1)	0	190 (5.2)
]20,...[	1,116 (30.4)	28 (0.8)	11 (0.3)	5 (0.1)	7 (0.2)	7 (0.2)	1174 (32.0)
Total	2841 (77.4)	418 (11.4)	259 (7.1)	104 (2.8)	30 (0.8)	19 (0.5)	3671 (100)

Supplementary Table 7: Matrix of shortest distances (km), comparing distance ranges from non-Indigenous localities (total number of localities and % in relation to total) to roads [line] and water bodies [column] (**minimum inundation** map):

Water bodies, high waters (km) / Roads (km)	[0, 1]	]1, 5]	]5,10]	]10, 15]	]15, 20]	]20, …[	Total
[0, 1]	633 (17.2)	299 (8.1)	218 (5.9)	120 (3.3)	79 (2.2)	62 (1.7)	1411 (38.4)
]1, 5]	327 (8.9)	24 (0.7)	5 (0.1)	6 (0.2)	1 (0.0)	5 (0.1)	368 (10.0)
]5,10]	267 (7.3)	9 (0.2)	5 (0.1)	2 (0.1)	1 (0.0)	1 (0.0)	285 (7.8)
]10, 15]	228 (6.2)	8 (0.2)	4 (0.1)	2 (0.1)	0	1 (0.0)	243 (6.6)
]15,20]	179 (4.9)	3 (0.1)	2 (0.1)	1 (0.0)	3 (0.1)	2 (0.1)	190 (5.2)
]20,...[	1067(29.1)	52 (1.4)	15 (0.4)	10 (0.3)	13 (0.4)	17 (0.5)	1174 (32.0)
Total	2701 (73.6)	395 (10.8)	249 (6.8)	141 (3.8)	97 (2.6)	88 (2.4)	3671 (100)

Our analysis is limited by the following factors: (1) there is not an updated and consistent road map for the Amazon basin. (2) this analysis does not refer to the quality of the roads. All roads are considered, even unpaved ones, therefore, some of these roads might not be suitable for certain types of vehicles; (3) Unpaved roads are known to be inadequate for transit during the rainy season in several parts of the Amazon. Therefore, existence of a road does not imply suitability for use; (4) Having roads nearby does not imply that they are well connected in a network. Some unpaved roads in the Amazon only lead to farms, but not to services or so. (5) We are aware that not all flooded areas are suitable for water transport. However, when considering modes of transportation by riverine communities of the Amazon, even small boats such as the "rabetas" (local name for a small, motorized boat) and the canoes with paddles should be considered, and for those, even 50 cm of depth is enough for transit.

We performed the same procedure to estimate the distance of indigenous villages (n = 2,521, FUNAI 2020)[10] to nearest water courses. In the same way, 15 points representing indigenous villages fell outside of the limits of the inundation area raster map. In addition, 381 other points represented indigenous villages that were visually inspected and observed to be close to rivers, although not well represented in the agreement map. For all these points, we also applied the above-mentioned procedure for correction.

Supplementary Table 8: Nearest distance between Indigenous villages and **inundation** area - Descriptive metrics:

(A) Nearest distance between Indigenous villages and **maximum** inundation area [km]:						
Min	1st Q	Median	Mean	3rd Q	Max	StDev
0.000586	0.292767	0.450680	1.363578	0.775495	20.438026	2.59643
(B) Nearest distance between Indigenous villages and **minimum** inundation area [km]:						
Min	1st Q	Median	Mean	3rd Q	Max	StDev
0.00059	0.31637	0.51292	2.98368	1.77995	41.00802	5.740463

Supplementary Table 9: Histograms for nearest distance between Indigenous villages (FUNAI 2020) and (A) **Maximum,** and (B) **Minimum** Agreement Inundation Map (Fleischmann et al. 2022):

interval	range [km]	abs number	freq rel	freq acum
1	0 - 1.7	2093	0.830226101	0.8302261
2	1.7 - 3.4	147	0.058310194	0.8885363
3	3.4 - 5.1	89	0.035303451	0.9238397
4	5.1 - 6.8	59	0.023403411	0.9472432
5	6.8 - 8.5	40	0.015866720	0.9631099
6	8.5 - 10.2	35	0.013883380	0.9769933
7	10.2 - 11.9	24	0.009520032	0.9865133
8	11.9 - 13.6	12	0.004760016	0.9912733
9	13.6 - 15.3	7	0.002776676	0.9940500
10	15.3 - 17.0	8	0.003173344	0.9972233
11	17.0 - 18.7	3	0.001190004	0.9984133
12	18.7 - 20.4	4	0.001586672	1

(A)

interval	range [km]	abs number	freq rel	freq acum
1	0 - 3.4	2008	0.796509322	0.7965093
2	3.4 - 6.8	158	0.062673542	0.8591829
3	6.8 - 10.2	73	0.028956763	0.8881396
4	10.2 - 13.7	88	0.034906783	0.9230464
5	13.7 - 17.1	71	0.028163427	0.9512098
6	17.1 - 20.5	57	0.022610075	0.9738199
7	20.5 - 23.9	30	0.011900040	0.9857200
8	23.9 - 27.3	16	0.006346688	0.9920666
9	27.3 - 30.7	12	0.004760016	0.9968267
10	30.7 - 34.2	3	0.001190004	0.9980167
11	34.2 - 37.6	4	0.001586672	0.9996033
12	37.6 - 42.0	1	0.000396668	1

(B)

Supplementary Table 10: Histograms for nearest distance between Indigenous villages (FUNAI 2020) and **roads**:

interval	range [km]	abs number	freq rel	freq acum
1	0 - 15	1514	0.600555335	0.6005553
2	15 - 31	329	0.130503768	0.7310591
3	31 - 46	285	0.113050377	0.8441095
4	46 - 61	183	0.072590242	0.9166997
5	61 - 76	98	0.038873463	0.9555732
6	76 - 92	38	0.015073384	0.9706466
7	92 - 107	30	0.011900040	0.9825466
8	107 - 122	15	0.005950020	0.9884966
9	122 - 137	9	0.003570012	0.9920666
10	137 - 153	5	0.001983340	0.9940500
11	153 - 168	5	0.001983340	0.9960333
12	168 - 184	10	0.003966680	1

Supplementary Table 11: Nearest distance between Indigenous villages and **roads** - Descriptive metrics:

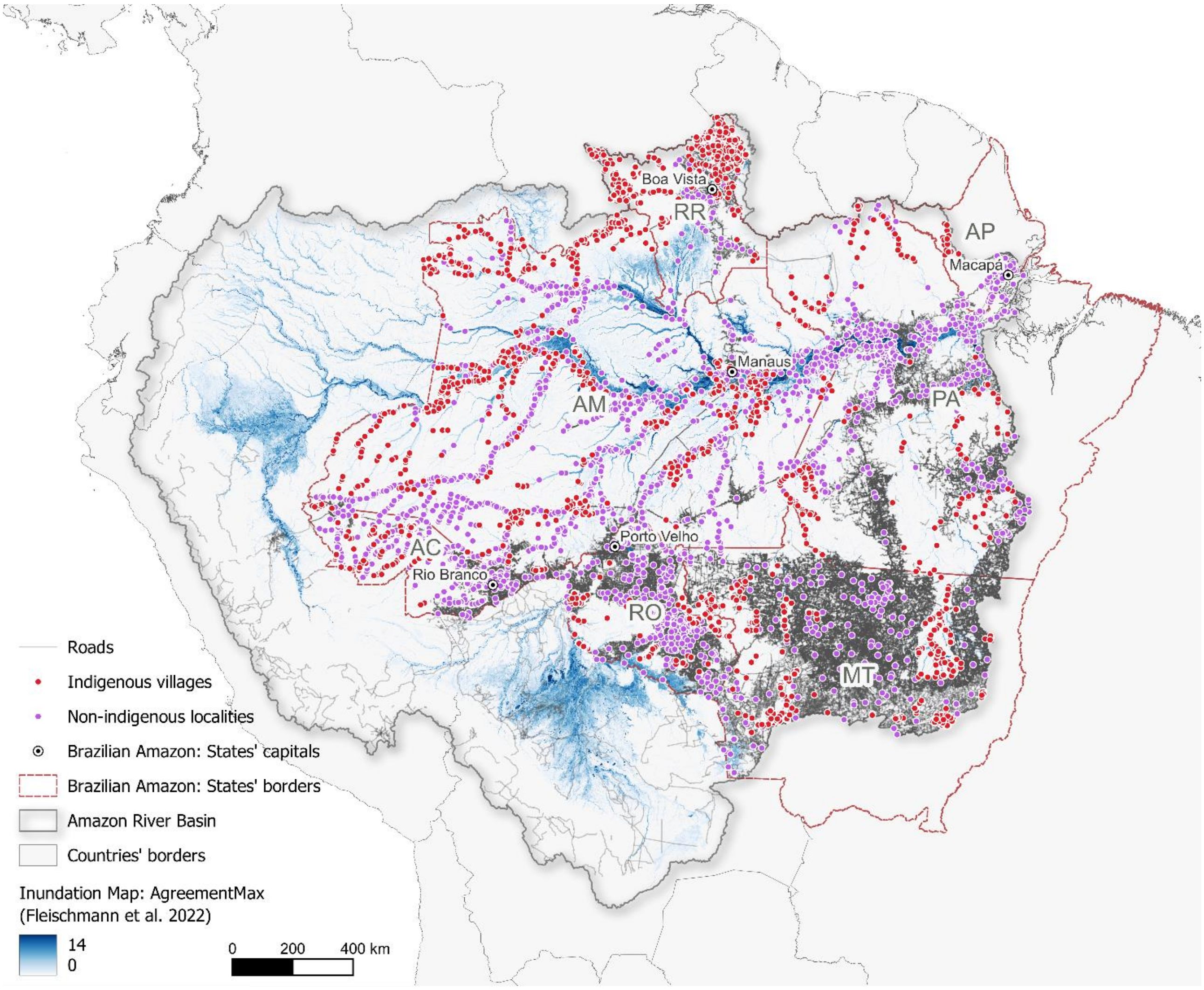
Min	1st Q	Median	Mean	3rd Q	Max	StDev
0.0003	0.4694	7.9347	20.5143	33.7410	183.2766	28.11125

Supplementary Table 12: Matrix of shortest distances (km), comparing distance ranges from Indigenous villages (total number of villages and % in relation to total) to roads [line] and water bodies [column] (**maximum inundation** map):

Water bodies, high waters (km) / Roads (km)	[0, 1]	]1, 5]	]5,10]	]10, 15]	]15, 20]	]20, …[	Total
[0, 1]	429 (17.0)	191 (7.6)	95 (3.8)	35 (1.4)	8 (0.3)	2 (0.1)	760 (30.1)
]1, 5]	285 (11.3)	61 (2.4)	18 (0.7)	6 (0.2)	1 (0.0)	0	371 (14.7)
]5,10]	202 (8.0)	20 (0.8)	3 (0.1)	0	0	0	225 (8.9)
]10, 15]	137 (5.4)	10 (0.4)	0	0	0	0	147 (5.8)
]15,20]	115 (4.6)	6 (0.2)	2 (0.1)	0	0	0	123 (4.9)
]20,...[	803 (31.9)	66 (2.6)	15 (0.6)	6 (0.2)	4 (0.2)	1 (0.0)	895 (35.5)
Total	1971 (78.2)	354 (14.0)	133 (5.3)	47 (1.9)	13 (0.5)	3 (0.1)	2521 (100)

Supplementary Table 13: Matrix of shortest distances (km), comparing distance ranges from Indigenous villages (total number of villages and % in relation to total) to roads [line] and water bodies [column] (**minimum inundation** map):

Water bodies, low waters (km) / Roads (km)	[0, 1]	]1, 5]	]5,10]	]10, 15]	]15, 20]	]20, …[	Total
[0, 1]	350 (13.9)	165 (6.5)	94 (3.7)	64 (2.5)	53 (2.1)	34 (1.3)	760 (30.1)
]1, 5]	251 (10.0)	68 (2.7)	16 (0.6)	13 (0.5)	14 (0.6)	9 (0.4)	371 (14.7)
]5,10]	186 (7.4)	17 (0.7)	9 (0.4)	8 (0.3)	2 (0.1)	3 (0.1)	225 (8.9)
]10, 15]	130 (5.2)	10 (0.4)	4 (0.2)	1 (0.0)	2 (0.1)	0	147 (5.8)
]15,20]	101 (4.0)	9 (0.4)	3 (0.1)	5 (0.2)	3 (0.1)	2 (0.1)	123 (4.9)
]20,...[	718 (28.5)	82 (3.3)	21 (0.8)	28 (1.1)	19 (0.8)	27 (1.1)	895 (35.5)
Total	1736 (68.9)	351 (13.9)	147 (5.8)	119 (4.7)	93 (3.7)	75 (3.0)	2521 (100)



Supplementary Figure 1: Amazon maximum inundation extent map (Fleischmann et al. 2022), overlayed by the combined map of roads, including paved and unpaved ones (CSR 2016, IMAZON 2012, SNV 2020). Red dots represent Indigenous villages of the Brazilian portion of the basin (FUNAI 2020). Pink dots represent non-Indigenous localities (remote rural settlements, villages & cities of the Brazilian portion of the basin, IBGE 2021). Brazilian Amazon States are identified by their abbreviation: AC (Acre); AM (Amazonas); AP (Amapá); MT (Mato Grosso); PA (Pará); RO (Rondônia); RR (Roraima).

Supplementary Note 2: Distribution of River Gauging Stations

The data were collected at river gauging stations managed by the Agência Nacional de Águas (ANA, National Water Agency). More information about the National Hydrometeorological Network (*Rede Hidrometeorológica Nacional – RHN*) can be found at https://metadados.snirh.gov.br/geonetwork/srv/api/records/f85dbf06-a869-414c-afc5-bb01869e9156 (only in Portuguese). Data were obtained online (https://www.snirh.gov.br/hidroweb/serieshistoricas) and processed using R packages from Tidyverse. The guidelines and manuals used to operate RHN stations can be found at https://www.gov.br/ana/pt-br/assuntos/monitoramento-e-eventos-criticos/monitoramento-hidrologico/orientacoes-manuais. Some documents are available in Portuguese and others in English.

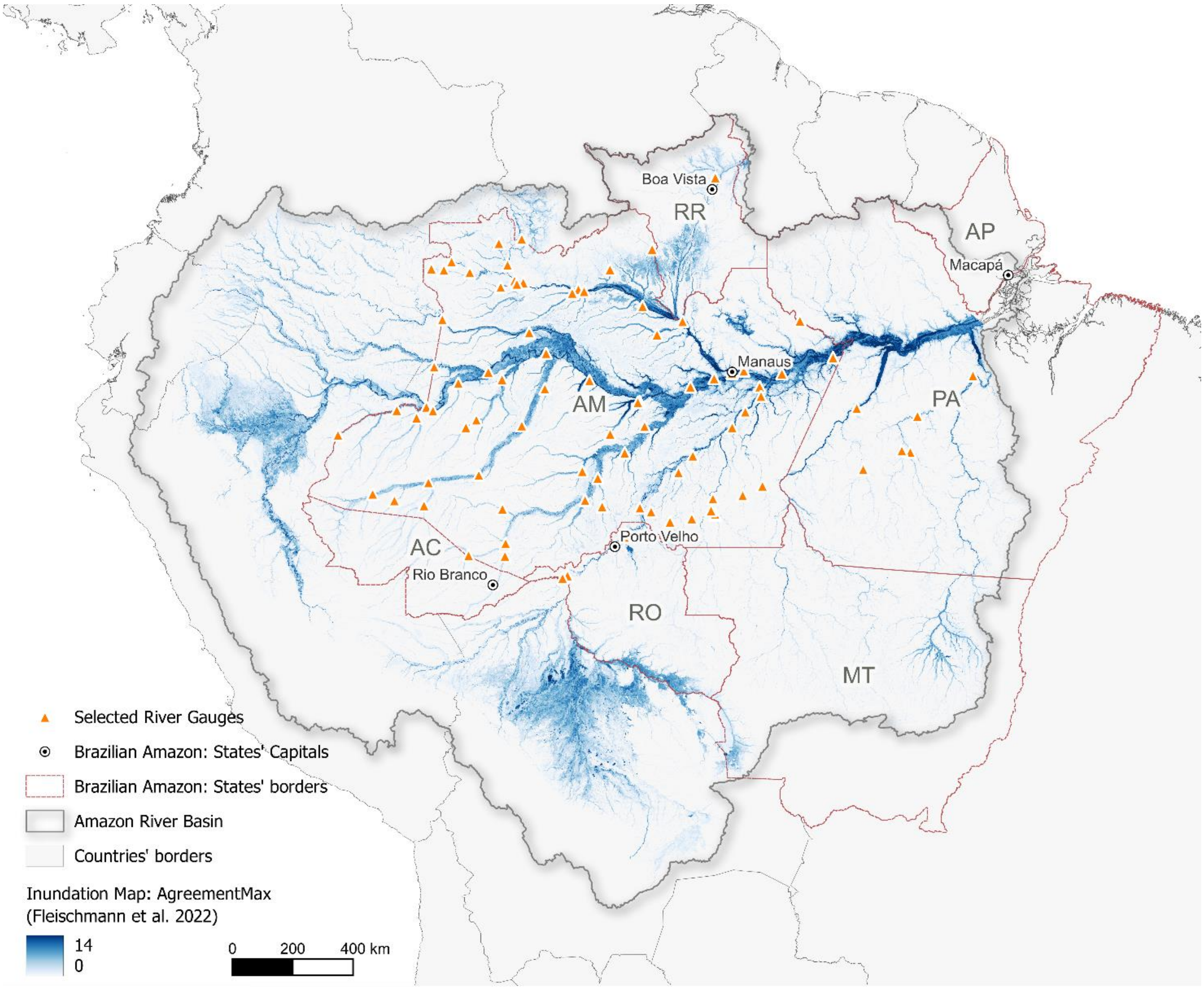
After applying the exclusion criteria to obtain adequate long time series of data for the analysis of the water level duration curves, our study counted with data from 90 river gauging stations. As for the exclusion criteria, we applied the following: (1) months with more than 10% of data gap; (2) incomplete years; (3) series with less than 15 complete years; (4) stations close to large dams.

Although we used data from 90 river gauging stations, the number of stations considered in each year of analysis varied due to different starting year of monitoring and the fact that several became deactivated after some years collecting data. Our period of analysis to derive reference P80 values for each station started in 1978 (although not all stations started collecting data back then) and ended in 2021. The minimum number of stations with adequate data for the analysis was reached in 1977-78 (39 stations), and the maximum in 2005-2006 (83 stations). As for the whole period of analysis, the median number of stations was 63. The total number of years used in the analysis for each station also varied according to the availability of adequate data (but always greater than 15 years). Please refer to the supplementary tabular data (see data availability statement) to check total number of years considered in the analysis for each station as well as total number of stations considered in each year.

River gauging stations excluded due to presence of nearby large dams (identified by their National Water Agency code):

1) 18865003
2) 16080000
3) 16100000
4) 15340500
5) 15340600
6) 15341000
7) 15360000
8) 15380000
9) 15400000
10) 15390000

Supplementary Figure 2 presents the location of the 90 river gauging stations.



Supplementary Figure 2: Spatial distribution of selected river gauging stations in the Brazilian portion of the Amazon basin (extracted from ANA, 2022). Brazilian Amazon States are identified by their abbreviation: AC (Acre); AM (Amazonas); AP (Amapá); MT (Mato Grosso); PA (Pará); RO (Rondônia); RR (Roraima). Administrative borders dataset from IBGE; Amazon maximum inundation extent map by Fleischmann et al. (2022). See Table S1 for data sources.

Supplementary References

1. Lehner, B., Verdin, K. & Jarvis, A. New global hydrography derived from spaceborne elevation data. *Eos (Washington DC)* **89**, 93–94 (2008).
2. Sistema de Proteção da Amazônia. Hidrografia Bifiliar - Espacialização da rede de drenagem bifiliar do Bioma Amazônico. http://www3.snirh.gov.br/portal/snirh (2009).
3. Instituto Nacional de Pesquisas Espaciais. TerraBrasilis. *INPE* http://terrabrasilis.dpi.inpe.br (2021).
4. Fleischmann, A. S. *et al.* How much inundation occurs in the Amazon River basin? *Remote Sens Environ* **278**, (2022).
5. Lehner, B. & Grill, G. Global river hydrography and network routing: Baseline data and new approaches to study the world’s large river systems. *Hydrol Process* **27**, 2171–2186 (2013).

6. IMAZON. Estradas não oficiais. *ImazonGeo - Geoinformação sobre a Amazônia* https://www.imazongeo.org.br/#/ (2012).
7. CSR-UFMG. Infraestrutura Panamazonia estradas vicinais. *CSR maps* https://maps.csr.ufmg.br/geodownload/?workspace=CSR&store=shp__infraestrutura__panamazonia__estradas_vicinais_pan_csr__estradas_vicinais_pan (2016).
8. DNIT. Plano Nacional de Viação e Sistema Nacional de Viação. *PNV e SNV* https://www.gov.br/dnit/pt-br/assuntos/atlas-e-mapas/pnv-e-snv (2020).
9. IBGE. Localidades. *Bases cartográficas contínuas - Brasil* (2021).
10. FUNAI. Aldeias. *Geoprocessamento e Mapas* https://www.gov.br/funai/pt-br/atuacao/terras-indigenas/geoprocessamento-e-mapas (2020).