



**Infrastructure Layers
(Transportation, Energy, Mining, Agribusiness, and Telecommunications)**

Appendix

Collection 8

Version 1

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1. About the Infrastructure Layers

The infrastructure layers available for download or online viewing on MapBiomass gather georeferenced information from transportation infrastructures (highways, railways, ports, etc.), energy (hydroelectric power plants, transmission lines, refineries, etc.), mining (coal mines, uranium mines, minerals mines, etc.), agribusiness (warehouses and slaughterhouses) and telecommunications (base radio stations). These layers may contribute to research regarding the correlation between land use change and infrastructure. When combined with other MapBiomass data, these layers can also assist on understanding production chains or logistical routes.

2. Overview of Infrastructure Layers

The MapBiomass Collection 3 (2018) incorporated into its land cover and land use maps the possibility of visualizing 36 layers referring to Brazilian energy and transportation infrastructures, such as highways, railways, oil refineries, or power plants. These layers were collected from different references prioritizing official sources (ANTAQ, IBGE, EPE, ANEEL, etc.). The layers were also organized according to chosen categories (Transportation, Power Sector, Fossil Fuels, etc.).

All these layers were revisited in Collection 4 (2019) to check for updates and/or better references. In the following 12 layers, some adjustments or updates were made: waterways, not identified pipelines, federal highways, gas delivery points, substations, transmission lines, wind power plants, photovoltaic power plants, biomass thermal power plants, hydroelectric power plants, small hydropower plants, and fossil fuel thermal power plants.

The most significant changes were made on all types of power plant layers. Collection 3 presented data from EPE, which only included information until 2016 and only listed higher power plants. Collection 4 presented more updated and comprehensive layers from ANEEL. This change in the information source explains the variation between plants number in Collection 3 (2138) and Collection 4 (6466).

Collection 5 (2020) maintained the same review process, and there was the addition of a new layer about hydroelectric generating plants under the "Energy" category and the inclusion of "Mining" as a new category of infrastructure.

In Collection 6 (2021), all the layers in Collection 5 were reviewed, and 18 layers were updated. Furthermore, State Highway was classified into a new group named General Highway Sections (Federal, State, and Other Highways) that includes federal, state, municipal, and privately owned roads, divided into 152656 road sections.

Collection 7 (2022) has some additions compared to Collection 6 besides the regular review. First, two new categories were included: agribusiness, with the warehouses and slaughterhouses layers, and telecommunications, with the base radio stations layer. Furthermore, the gas pipeline layer was subdivided into transportation, distribution, and outflow gas pipelines, and the layer airway was subdivided into public

airfield, private airfield, and helipad layers. The layers of liquefied natural gas terminals (energy), and mining dam (mining) were also added, and the subcategories “Highway” and “Waterway” were rearranged with the new “other road sections” and “other port facilities” layers, respectively. Collection 8 followed the same method used in Collection 7.

Thus, MapBiomass currently presents 51 layers of infrastructure organized as lines or points. When possible, the infrastructure installation years were added to the layers as complementary information. Buffers of 5, 10, and 20 km radius have also been generated around most of these layers. After that, land use in these polygons was calculated. A new feature in Collection 7 is the possibility to see a label for almost all layers in the MapBiomass platform when you get close to them. This label shows the specific name of the selected infrastructure and other information for some layers.

It is worth mentioning that this work of cyclical systematization and gathering of infrastructure layers is important to understand how infrastructures influence land use changes and to qualify decision-making processes that ensure the sustainable use of natural resources with social and economic development. This information was spread through several portals. The fact that all these data sets are now gathered in one portal (MapBiomass) also enhances their uses, enabling new analyses and motivating official organizations to improve the quality and frequency of their information.

The following figure illustrates the federal highway layer visualization through the MapBiomass online platform. Details about each one of the available layers can be found in the next topic.



Figure 1. Hydroelectric Power Plant Layer in MapBiomass (2021).

3. Glossary

Table 1. Glossary – Transportation Layers.

LAYER (HIERARCHY)	DEFINITION	N. OF ELEMENTS OF INTEREST	REF. LAYER	TIME AVAILABLE DATA	REFERENCE (TIME DATA)	BUFFER	LAST UPDATE
1. Transportation							
1.1 Airway							
1.1.1 Public airfield	Area destined for aircraft landing, taking off, and moving. (Ref. ANAC)	438	[1] ANAC	1925 - 2005	[11]	Yes	Collection 7
1.1.2 Private airfield	Area destined for aircraft landing, taking off, and moving. (Ref. ANAC)	2710	[1] ANAC	-	-	Yes	Collection 7
1.1.3 Helipad	Private helipads in operation. (Ref. ANAC)	1335	[1] ANAC	-	-	Yes	Collection 7
1.2 Waterway							
1.2.1 Lock	Hydraulic engineering device used for raising and lowering watercraft between stretches of water of different levels in rivers or canal waterways (dams, waterfalls, or rapids). Locks work as steps or lifts for watercraft. (Ref. DNIT)	17	[2] IBGE	1958 - 2010	[12][13]	Yes	Collection 7
1.2.2 Transshipment Station	Station located outside the organized port area, exclusively used for transshipment operations of cargo destined for or coming from inland waterways. (Ref. DNIT)	40	[3] ANTAQ	-	-	Yes	Collection 7
1.2.3 Waterway	Navigable body of water within a river, lagoon or artificial channel with dimensions and parameters standardized, according to engineering criteria. (Ref. DNIT)	110	[2] IBGE	-	-	Yes	Collection 7
1.2.4 Port Facility for Tourism	Port facility operated by lease or authorization and used for boarding, landing, and transit of passengers, crew, baggage, and supplies for the tourism vessels. (Ref. Law N° 12.815 - 2013 - BR)	3	[3] ANTAQ	-	-	Yes	Collection 7
1.2.5 Registered Port Facility	Installation located inside or outside the organized port area, used for the passenger transportation, or cargo storage, destined for or coming from waterway transport. (Ref. DNIT)	272	[3] ANTAQ	-	[3]	Yes	Collection 7
1.2.6 Organized Port	Infrastructure constructed and equipped to meet the needs of navigation, passengers' transportation or cargo movement and storage, granted or operated by the Union, whose traffic and operations are under the jurisdiction of a port authority. (Ref. DNIT)	108	[3] ANTAQ	1856 - 1986	[14] - [32]	Yes	Collection 7
1.2.7 Private Use Terminal	Installation, not part of the assets of the public port, built by a private company or public entity for the handling or storage of third-party cargo, in addition to the own cargo, destined for or coming from waterway transport. (Ref. ANTAQ)	179	[3] ANTAQ	-	-	Yes	Collection 7
1.2.8 Other port facilities	Other port facilities not yet covered by the previous layers.	38	[2] IBGE	-	-	Yes	Collection 7
1.3 Pipeline							
1.3.1 Aqueduct	Pipeline network used for water transportation.	5	[4] Minfra	-	-	Yes	Collection 3
1.3.2 Gas Pipeline							
1.3.2.1 Transportation gas Pipeline	Pipeline that moves natural gas from processing, storage or other transportation pipeline facilities to storage facilities, other transportation pipelines and delivery points to state natural gas distribution concessionaires. (Ref. MME)	56	[5] EPE	1970 - 2011	[4]	Yes	Collection 7
1.3.2.2 Distribution gas pipeline	Part of the infrastructure of distribution concessionaires, it receives natural gas at the point of delivery (City Gate) and delivers it to final consumers, completing the gas chain.	19	[5] EPE	-	-	No	Collection 7
1.3.2.3 Outflow gas Pipeline	Pipelines that are part of production facilities, intended for the movement of natural gas from producing goods to processing and treatment facilities or liquefaction units. (Ref. MME)	282	[5] EPE	-	-	Yes	Collection 7
1.3.3 Mining pipeline	Pipeline network used for ore transportation.	5	[4] Minfra	-	-	Yes	Collection 3
1.3.4 Oil Pipeline	Pipeline network used for oil transportation.	370	[4] Minfra	-	-	Yes	Collection 3
1.3.5 Polyduct	Pipeline network used to transport more than one product.	74	[4] Minfra	-	-	Yes	Collection 3
1.3.6 Not Identified	Pipeline network used to transport unidentified products.	19	[4] Minfra	-	-	Yes	Collection 4
1.4 Railroad	Rail transport system consisting of rail and other fixed installations, rolling stock, traffic equipment and everything else necessary for the safe and efficient handling of passengers and cargo. (Ref. DNIT)	2244	[4] Minfra	1884 - 1996	[33]-[35]	Yes	Collection 7
1.5 Highway							
1.5.1 State Highway	Road under state responsibility.	32910	[2] IBGE	-	-	Yes	Collection 7
1.5.2 Federal Highway	Road under federal responsibility.	14255	[2] IBGE	-	-	Yes	Collection 7

1.5.3 Other road sections	Other types of road sections in addition to highways and/or highways that are not federal or state responsibility.	81197	[2] IBGE	-	-	Yes	Collection 7
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Table 2. Glossary – Energy Layers.

LAYER (HIERARCHY)	DEFINITION	N. OF ELEMENTS OF INTEREST	REF. LAYER	TIME AVAILABLE DATA	REFERENCE (TIME DATA)	BUFFER	LAST UPDATE
2. Energy							
2.1 Fuels							
2.1.1 Fossil Fuels							
2.1.1.1 Liquid Fuels							
2.1.1.1.1 Oil Refineries and Other Processing Facilities	Facilities responsible for feedstock processing into products of interest.	23	[5] EPE	1937 - 2013	[5][42]-[45]	Yes	Collection 6
2.1.1.1.2 Oil and Oil Products Storage and Distribution Terminal	Facilities used for receiving, shipping, and storing oil and oil products. (Ref. ANP)	117	[5] EPE	-	-	Yes	Collection 6
2.1.1.2 Gas							
2.1.1.2.1 Compression Station	Facilities responsible for compressing gas to pipeline transportation.	33	[5] EPE	1986 - 2010	[36]-[40]	Yes	Collection 7
2.1.1.2.2 Gas Delivery Point	Facilities responsible for decompressing natural gas for local distribution companies.	184	[5] EPE	-	-	Yes	Collection 7
2.1.1.2.3 Natural Gas Processing Unit	Facilities where wet natural gas heavier fractions (propane and heavier substances) are separated, generating dry or poor natural gas (methane and ethane).	16	[5] EPE	1962 - 2020	[5]	Yes	Collection 6
2.1.1.2.4. Liquefied Natural Gas Terminals	Installation used for the liquefaction of natural gas or for the import, discharge, and regasification of LNG, including auxiliary services and temporary storage tanks necessary for the regasification process and subsequent delivery of natural gas to the pipeline network or other modes of transport.	21	[5] EPE	-	-	Yes	Collection 7
2.1.2 Renewable Fuels							
2.1.2.1 Biodiesel Plant	Plants for biodiesel production.	64	[5] EPE	2008 - 2022	[41]	Yes	Collection 6
2.1.2.2 Biogas Plant	Plants for biogas production.	543	[5] EPE	2003 - 2019	[5]	Yes	Collection 6
2.1.2.3 Ethanol Plant	Plants for ethanol production.	397	[5] EPE	1883 - 2016	[5]	Yes	Collection 6
2.1.3 Distribution Bases							
2.1.3.1 Liquefied Petroleum Gas Base	Installations for storage and distribution of liquefied petroleum gas (LPG).	179	[5] EPE	1998-2022	[5]	Yes	Collection 7
2.1.3.2 Liquid Fuel Base	Installations for fuel storage and distribution.	276	[5] EPE	-	-	Yes	Collection 6
2.2 Power Sector							
2.2.1 Infrastructure							
2.2.1.1 Substation	Set of machines, devices, and circuits whose purpose is to modify the voltage and current levels, allowing the distribution of electric energy to diverse systems and lines. (Ref. USP)	780	[5] EPE	1953 - 2022	[5]	Yes	Collection 7
2.2.1.2 Transmission Line	Transmission line is a system formed by cables of conductive material, supported by towers (metallic structures), used to transmit electromagnetic energy.	1712	[5] EPE	1962 - 2022	[5]	Yes	Collection 7
2.2.2 Generation							
2.2.2.1 Renewable Generation							
2.2.2.1.1 Wind Power Plant	Power plants that transform mechanical energy from wind into electricity.	993	[6] ANEEL	1998 - 2022	[6]	Yes	Collection 7
2.2.2.1.2 Photovoltaic Solar Power Plant	Power plants that transform energy from solar radiation into electricity.	11391	[6] ANEEL	1961 - 2022	[6]	Yes	Collection 7
2.2.2.1.3 Biomass Thermal Power Plant	Power plants that use biomass (e.g., sugarcane bagasse) as fuel for obtaining heat (thermal energy), generating mechanical energy and later electricity.	627	[6] ANEEL	1905 - 2022	[6]	Yes	Collection 7
2.2.2.1.4 Hydroelectric Power Plant	Hydraulic power plants, with capacity higher than 30 MW, which transform energy from a height difference in a watercourse into electricity.	164	[6] ANEEL	1900 - 2019	[6]	Yes	Collection 7
2.2.2.1.5 Small Hydropower Plant	Medium hydroelectric plants that transform energy from a height difference in a watercourse into electricity.	392	[6] ANEEL	1908 - 2020	[6]	Yes	Collection 7
2.2.2.1.6 Hydroelectric Generating Centers	Small hydroelectric plants that transform energy from a height difference in a watercourse into electricity.	859	[6] ANEEL	1900 - 2020	[6]	Yes	Collection 7
2.2.2.2 Non-Renewable Generation					[6]		

2.2.2.2.1 Fossil Fuel Thermal Power Plant	Plants that use fossil fuels to obtain heat (thermal energy), generating mechanical energy and, later, electricity.	2548	[6] ANEEL	1908 - 2022	[6]	Yes	Collection 7
2.2.2.2.2 Thermonuclear Power Plant	Plants that use nuclear energy to obtain heat (thermal energy), generating mechanical energy and, later, electricity.	3	[6] ANEEL	1985 - 2001	[6]	Yes	Collection 3

Table 3. Glossary – Mining Layers.

LAYER (HIERARCHY)	DEFINITION	N. OF ELEMENTS OF INTEREST	REF. LAYER	TIME AVAILABLE DATA	REFERENCE (TIME DATA)	BUFFER	LAST UPDATE
3. Mining							
3.1 Energetic Product Mine	Mining facilities for coal or uranium, products used in the energy production.	14	[7] AHK	2018-2022	[7]	Yes	Collection 5
3.2 Metálicas Product Mine	Mining facilities for different types of minerals and metals: bauxite, cassiterite, lead, cobalt, copper, chromite, iron, lithium, manganese, niobium, nickel, gold, rare earth elements, tungsten, vanadium, zinc.	106	[7] AHK	2018-2022	[7]	Yes	Collection 5
3.3 Other Products Mine	Mining facilities for different types of minerals: agalmatolite, asbestos, limestone, kaolin, diamond, feldspar, phyllite, phosphate, ilmenite, potassium, talc, vermiculite.	62	[7] AHK	2019-2023	[7]	Yes	Collection 5
3.4 Mining Dam	Any structure built inside or outside a permanent or temporary watercourse, in a thalweg or in a ditched pit, for the purpose of containment or accumulation of liquid substances or mixtures of liquids and solids, comprising the dam and associated structures. (Ref. SNISB)	62	[8] ANM	2019-2023	[8]	Yes	Collection 7

Table 4. Glossary – Agribusiness Layers.

LAYER (HIERARCHY)	DEFINITION	N. OF ELEMENTS OF INTEREST	REF. LAYER	TIME AVAILABLE DATA	REFERENCE (TIME DATA)	BUFFER	LAST UPDATE
4. Agribusiness							
4.1 Warehouses	Warehouses for agricultural production stock.	16676	[9] LAFIG	2018-2022	-	Yes	Collection 7
4.2 Slaughterhouse	Industrial facility that carries out the processing and storage of products of animal origin.	207	[9] LAFIG	1948-2021	[9]	Yes	Collection 7

Table 5. Glossary – Telecommunications Layer.

LAYER (HIERARCHY)	DEFINITION	N. OF ELEMENTS OF INTEREST	REF. LAYER	TIME AVAILABLE DATA	REFERENCE (TIME DATA)	BUFFER	LAST UPDATE
5. Telecommunications							
5.1 Base radio station	Equipment that makes the connection between cell phones and the telephone company.	99455	[10] Conexis.org	-	-	Yes	Collection 7

4. References

- [1] Agência Nacional de Aviação Civil. Aeródromos. <https://www.anac.gov.br/aceso-a-informacao/dados-abertos/areas-de-atuacao/aerodromos/lista-de-aerodromos-publicos-v2> (2022).
- [2] Instituto Brasileiro de Geografia e Estatística (IBGE). Bases Cartográficas Contínuas (Versão 2021). https://geoftp.ibge.gov.br/cartas_e_mapas/bases_cartograficas_continuas/bc250/ (2022)
- [3] Agência Nacional de Transportes Aquaviários (ANTAQ). Informações Geográficas. <https://www.gov.br/antag/pt-br/central-de-conteudos/informacoes-geograficas> (2022).
- [4] Ministério da Infraestrutura (MInfra). Mapas e Bases dos Modos de Transportes. <https://www.gov.br/infraestrutura/pt-br/assuntos/dados-de-transportes/bit/bitmodosmapas#mapport> (2022).
- [5] Empresa de Pesquisa Energética (EPE). Sistema de Informações Geográficas do Setor Energético Brasileiro (Web Map EPE). <https://gisepeprd2.epe.gov.br/WebMapEPE/> (2021).
- [6] Agência Nacional de Energia Elétrica (ANEEL). Sistema de Informações de Geração (SIGA). <https://app.powerbi.com/view?r=eyJrIjoiNjc4OGYyYjQtYWM2ZC00YjllLWJlYmEtYzdkNTQ1MTc1NjM2liwidCI6IjQwZDZmOWI4LWVjYTctNDZhMi05MmQ0LWVhNGU5YzAxNzBIMSIsImMiOiR9/> (2022).
- [7] Câmara de Comércio e Indústria Brasil-Alemanha. Mapa da Mineração Brasileira. <https://www.ahkbrasilien.com.br/projetos/mineracao/mapa-da-mineracao-brasileira/> (2020).
- [8] Agência Nacional de Mineração. Barragem. <https://app.anm.gov.br/dadosabertos/BARRAGEM> (2022).
- [9] Laboratório de Processamento de Imagens e Geoprocessamento (LAPIG). Atlas das Pastagens. <https://lapig.iesa.ufg.br/p/38972-atlas-das-pastagens> (2022).
- [10] Conexis.org. Mapa de antenas. <https://conexis.org.br/numeros/mapa-de-antenas/> (2022).
- [11] Wikipédia. Lista de Aeroportos do Brasil. https://pt.wikipedia.org/wiki/Lista_de_aeroportos_do_Brasil (2018).
- [12] Departamento Hidroviário do Governo do Estado de São Paulo. Eclusas. <http://www.dh.sp.gov.br/eclusagem/> (2018).
- [13] Departamento Nacional de Infraestrutura de Transportes (DNIT). Obras da Diretoria Aquaviária – Eclusas. https://www.gov.br/dnit/pt-br/assuntos/aquaviario/eclusas_nova (2022).

- [14] Agência Nacional de Transportes Aquaviários (ANTAQ). Portos. <http://antag.gov.br/Portal/pdf/Portos/2012/Antonina.pdf> (2018).
- [15] Cia Docas do Rio Grande do Norte (CODERN). <http://codern.com.br/> (2018).
- [16] Porto de Cabedelo. História. <http://portodecabedelo.pb.gov.br/porto/historia/> (2018).
- [17] Administração do Porto de São Francisco do Sul (APSFS). Revista 60 Anos do Porto de São Francisco do Sul. <http://www.apsfs.sc.gov.br/wp-content/uploads/2014/01/Revista60anosdoPortodeSaoFranciscodoSul.pdf> (2018).
- [18] Companhia Docas do Pará (CDP). <http://www.cdp.com.br/> (2018).
- [19] Companhia Docas do Estado da Bahia (CODEBA). <http://www.codeba.com.br/eficiente/sites/portalcodoba/pt-br/home.php> (2018).
- [20] Docas de Santana. O Porto. <http://www.docasdesantana.com.br/index.php/o-porto> (2018).
- [21] Empresa Maranhense de Administração Portuária (EMAP). Porto do Itaqui – Histórico. <http://www.emap.ma.gov.br/porto-do-itaqui/historico> (2018).
- [22] Porto de Imbituba. Histórico. <http://www.portodeimbituba.com.br/site/porto/> (2018).
- [23] Porto de Maceió. História. <http://www.portodemaceio.com.br/portal/index.php/porto-de-maceio/historia> (2018).
- [24] Porto de Santos. História. <https://www.portodesantos.com.br/conheca-o-porto/historia-2/>(2018).
- [25] Porto do Forno. História. <http://www.portodoforno.com.br/historia-porto-do-forno> (2018).
- [26] Porto do Recife. História. <http://www.portodorecife.pe.gov.br/historia.php> (2018).
- [27] Porto de Itajaí. Histórico. <https://www.portoitajai.com.br/historia> (2018).
- [28] Porto Rio Grande. Histórico. https://www.embrapa.br/macrologistica/exportacao/porto_rio-grande (2021).
- [29] Portos do Paraná. <http://www.portosdoparana.pr.gov.br/modules/conteudo/conteudo.php?conteudo=26> (2018).
- [30] Docas do Rio. <http://www.portosrio.gov.br/> (2018).
- [31] Complexo Industrial Portuário Governador Eraldo Gueiros (SUAPE). Histórico. <http://www.suape.pe.gov.br/pt/institucional/historico-de-suape> (2018).
- [32] Wikipédia. Lista de Portos do Brasil. https://pt.wikipedia.org/wiki/Lista_de_portos_do_Brasil (2018).
- [33] Ferrovia Tereza Cristina (FTC). História.

<https://www.ftc.com.br/historia> (2021).

[34] Vale. Estrada de Ferro Carajás: o caminho onde passa a nossa riqueza.
<http://www.vale.com/brasil/PT/initiatives/innovation/carajas-railway/Paginas/default.aspx> (2018).

[35] Wikipédia. Lista de Ferrovias do Brasil.
https://pt.wikipedia.org/wiki/Lista_de_ferrovias_do_Brasil (2018).

[36] Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP). Autorização ANP Nº 472, de 29.7.2010 - DOU 30.7.2010.
<http://legislacao.anp.gov.br/?path=legislacao-anp/autorizacoes/2010/julho&item=aut-472--2010> (2018).

[37] GeoGás. Projetos Congonhas.
<http://geogas.com.br/portfolio/estacao-de-compressao-de-congonhas-gasbel/> (2021)

[38] Petrobras. Gasodutos.
<http://www.petrobras.com.br/pt/nossas-atividades/principais-operacoes/gasodutos/> (2018).

[39] Portal Fator Brasil. Petrobras inaugura gasoduto Cabiúnas-Reduc III (Gasduc III).
http://www.revistafatorbrasil.com.br/ver_noticia.php?not=105033 (2018).

[40] TBG. Informações Técnicas.
<https://www.tbg.com.br/historia-de-pioneirismo> (2021).

[41] Associação dos Produtores de Biodiesel do Brasil (APROBIO). Base de Usinas de Biodiesel (Anos de Inauguração) (2021).

[42] Refinaria Rio Grandense. Histórico.
<http://www.refinariariograndense.com.br/site/Pages/refinaria/historia/historia.aspx> (2021).

[43] Refinaria Manguinhos. Home.
<http://www.refinariademanguinhos.com/>

[44] Petrobras. Unidade de Industrialização do Xisto (SIX).
<https://petrobras.com.br/pt/nossas-atividades/principais-operacoes/refinarias/unidade-de-industrializacao-do-xisto-six.htm> (2021)

[45] Petrobras. Refinaria Landulpho Alves (RLAM).
<https://petrobras.com.br/pt/nossas-atividades/principais-operacoes/refinarias/refinaria-landulpho-alves-rlam.htm> (2021)