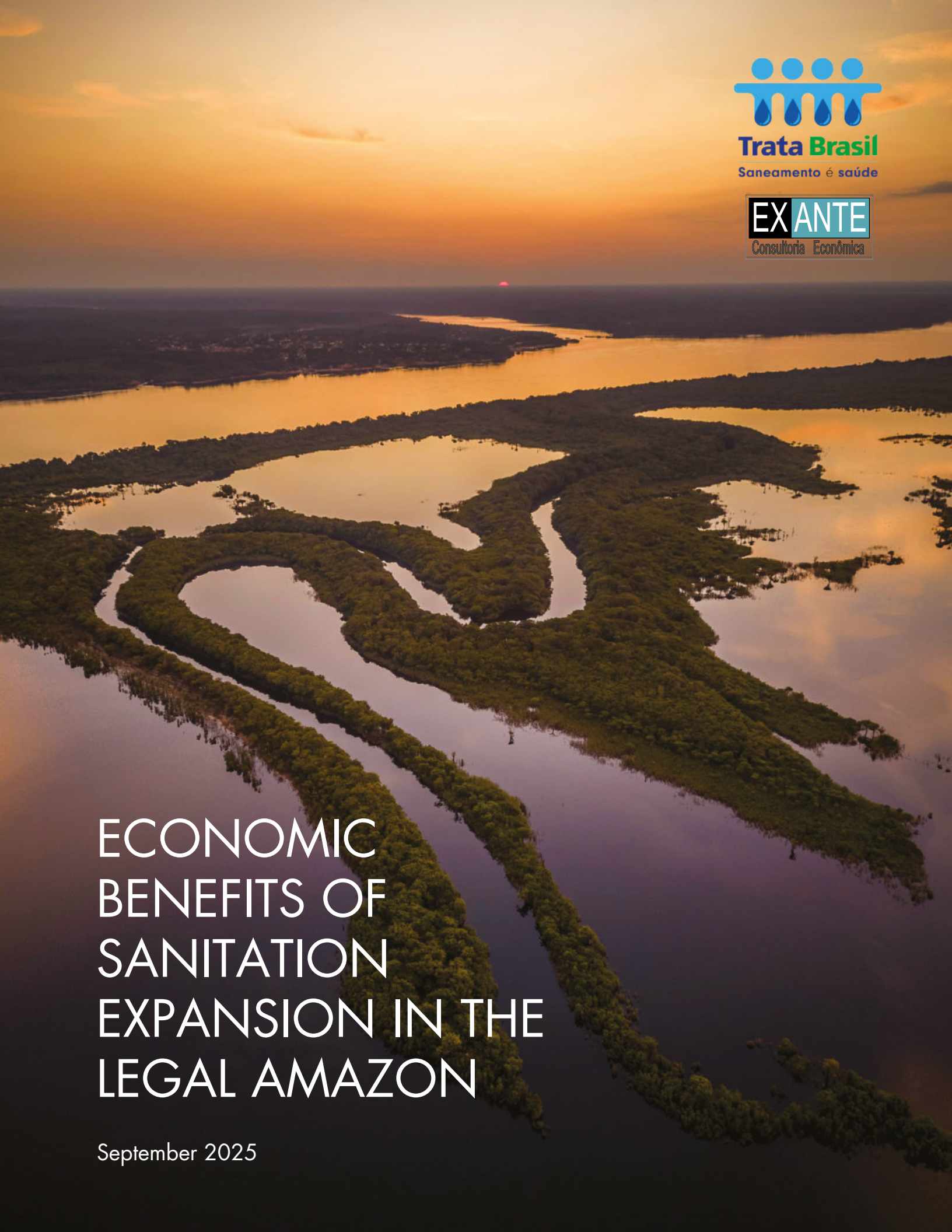

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EX ANTE
Consultoria Econômica

ECONOMIC BENEFITS OF SANITATION EXPANSION IN THE LEGAL AMAZON

September 2025

Table of Contents

ANALYSIS PREPARED BY:

EX ANTE Consultoria Econômica

DR. FERNANDO GARCIA DE FREITAS
DRA. ANA LELIA MAGNABOSCO

1

OBJECTIVES, SCOPE, AND METHODOLOGY OF THE STUDY

The Legal Amazon is a region within Brazilian territory created in 1950 with the objective of guiding the country's territorial occupation and promoting regional development. Today, the importance of the Legal Amazon is directly associated with environmental preservation and the protection of traditional peoples, who play a major role in maintaining the forests.

This study aims to assess the progress of basic sanitation in this region and to analyze the potential effects of universal access to sanitation. The analysis is based on socioeconomic data, disease incidence, and access to sanitation services in the municipalities that are part of the Legal Amazon. The main highlights of these analyses are the direct and indirect benefits, as well as the costs incurred with the expected expansion of sanitation services in these cities. The study provides both a historical view of the costs and benefits of sanitation progress between 2005 and 2023 and a forward-looking view of the potential through 2040, the deadline for universal access to sanitation services according to the new sanitation regulatory framework. Although the analysis extends to 2040, it is worth noting that a significant portion of the municipalities are expected to reach universal access by 2033, as set forth in the goals. In addition, the study also analyzes the longer-term effects that constitute the legacy of universal access to sanitation.

1.1. METHODOLOGY

The methodology of the study takes as its analytical reference the research conducted by the Trata Brasil Institute on the economic benefits of sanitation in Brazil. This methodology has been developed by Trata Brasil for more than

12 years and has been employed in studies with national, state, and municipal focus.

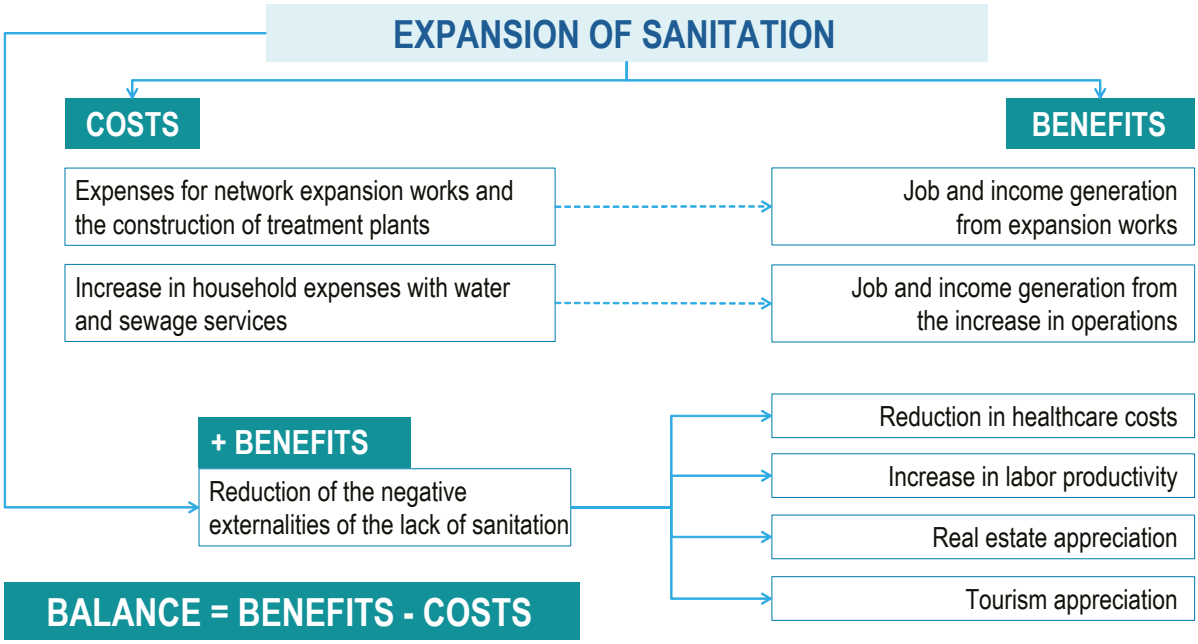
More recently, the methodology has been adapted to cover regional dimensions that do not directly correspond to administrative territorial boundaries, such as river basins and the Legal Amazon region itself.

Figure 1.1 briefly describes the methodology. The main objective of the analysis is to compare the social costs of sanitation expansion with the benefits gained by society through the expansion of services. The costs are measured directly and consider the investments made for the expansion and maintenance of water supply and sewage collection networks, the construction and maintenance of water and sewage treatment plants, and the installation and maintenance of all equipment necessary for system operation.

In addition to these capital expenditures, which are borne by system operators, the expansion of sanitation also leads to increased household expenses to cover the system's operational costs.

These costs, however, generate direct benefits, insofar as the expenditures of one part of society represent revenues for the companies that produce the goods and services related to these investments, such as construction firms and manufacturers of machinery, equipment, and construction materials, as well as for the companies that operate sanitation systems, producing and distributing treated water and collecting and treating sewage. In this sense, these costs involve financial resources that circulate within society but remain in the economy, generating jobs and income. From this increase in capital and the growth of operations, therefore, direct benefits are generated for society.

Figure 1.1
Methodological Framework



Source: Ex Ante Consultoria Econômica.

In addition to the direct benefits, the expansion of sanitation brings with it the reduction of negative externalities that exist due to the lack of sanitation. These negative externalities include the expenses incurred by society as a result of diseases that affect the health of populations without access to sanitation, such as waterborne diseases and respiratory illnesses (such as flu and pneumonia). The occurrence of these diseases causes people to be absent from their routine activities and, in more severe cases, to be bedridden or hospitalized, often leading to very serious health conditions that may result in death.

Thus, the incidence of these diseases generates healthcare expenses, affects worker productivity, reduces school performance among children and young people, and causes environmental devaluation, with consequences for the real estate market and economic activities such as tourism. On the other hand, the advancement of sanitation effectively reduces the incidence of these diseases, allowing for a reduction in healthcare costs, an increase in labor productivity, appreciation of real estate, and growth in tourism. The progress of sanitation therefore brings indirect benefits through the reduction of negative externalities, positively affecting the balance between the costs and social benefits of these undertakings.

The following analysis was developed entirely with public information from the Brazilian Statistical System. The demographic and socioeconomic data come from IBGE databases. The sanitation information comes from the National Sanitation Information System (SNIS) of the Ministry of Cities. In addition to these core data sources for the analysis, other IBGE surveys are employed: the 2023 National Household Sample Survey, the 2019 National Health Survey, the 2023 Annual Survey of the Construction Industry, the 2022 Annual Survey of Services, and Brazil's 2022 National Accounts. Information on the number and costs of hospitalizations due to waterborne diseases and respiratory illnesses paid for by the Unified Health System (SUS) comes from DATASUS. Information on ENEM performance was obtained from INEP of the Ministry of Education, and employment data are from the Ministry of Labor.

Since the frequency and timeliness of the surveys vary widely, the rule adopted was to use the most recent data available for each analysis. For example, DATASUS data provide information up to 2024, and the National Household Sample Survey provides information up to 2023. In the specific case of sanitation information, we opted to conduct an analysis that considered the broadest possible coverage while ensuring reliability. The SNIS database from 2000 to 2004 has limited coverage of municipalities in the Legal Amazon. The SINISA database, which replaced SNIS starting in 2023, also suffers from this limitation, as between 2022 and 2023 coverage was sharply reduced, in addition to issues related to slight methodological changes between the two databases.

1.2. MUNICIPALITIES COVERED AND THEIR ECONOMIC IMPORTANCE

The Legal Amazon encompasses the entire Northern region of the country, the state of Mato Grosso, and the western part of the state of Maranhão, which is demarcated by the 44th

Map 1.1
Boundary of the Legal Amazon, 2022

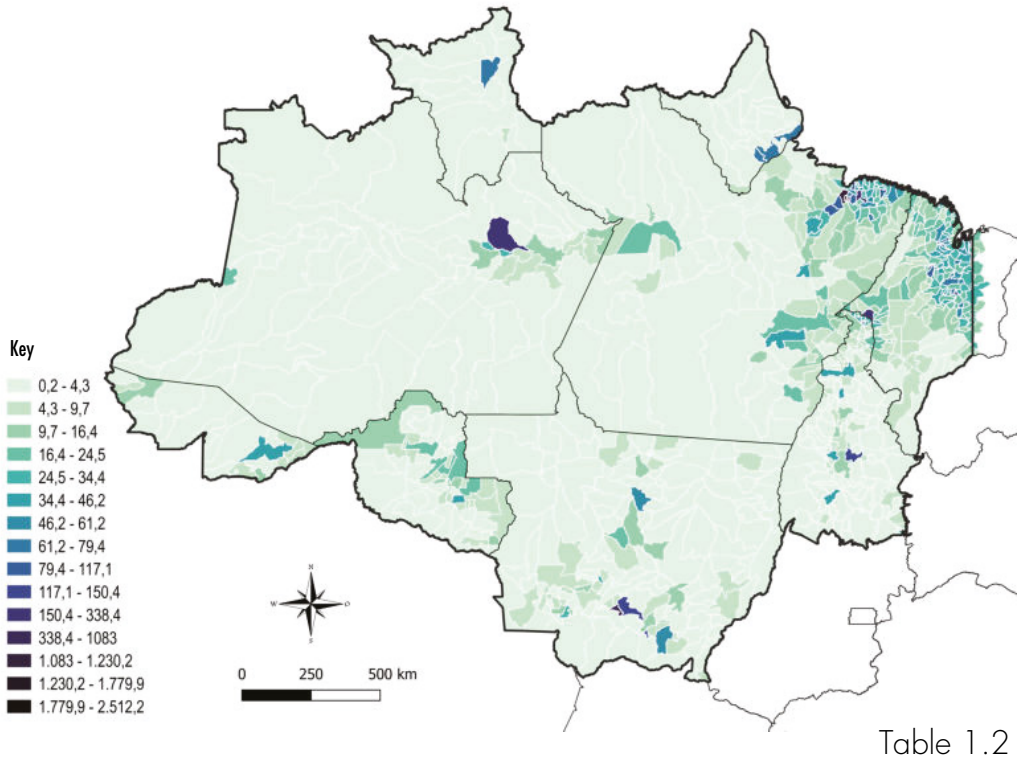
Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

Table 1.1
Demographic Data of the Legal Amazon, 2022

	Population		Area		Density	
	Inhabitants	(%) of Brasil	Km²	(%) of Brazil	Hab/Km²	(%) of Brazil
Brazil	203.080.756	100,0%	8.510.417,82	100,0%	23,86	100,0%
Legal Amazon	**26.650.798**	**13,1%**	**5.030.185,73**	**59,1%**	**5,30**	**22,2%**
Regions						
Western	6.989.534	3,4%	2.184.828,01	25,7%	3,20	13,4%
Eastern	19.661.264	9,7%	2.845.357,72	33,4%	6,91	29,0%
States						
Rondônia	1.581.196	0,8%	237.754,17	2,8%	6,65	27,9%
Acre	830.018	0,4%	164.173,43	1,9%	5,06	21,2%
Amazonas	3.941.613	1,9%	1.559.255,88	18,3%	2,53	10,6%
Roraima	636.707	0,3%	223.644,53	2,6%	2,85	11,9%
Pará	8.120.131	4,0%	1.245.870,71	14,6%	6,52	27,3%
Amapá	733.759	0,4%	142.470,76	1,7%	5,15	21,6%
Tocantins	1.511.460	0,7%	277.423,63	3,3%	5,45	22,8%
Maranhão	5.637.265	2,8%	276.384,25	3,2%	20,40	85,5%
Mato Grosso	3.658.649	1,8%	903.208,36	10,6%	4,05	17,0%

Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

Map 1.2
Population Density in the Municipalities of the Legal Amazon, 2022



Source: IBGE.
Prepared by: Ex Ante Consultoria Econômica.

Table 1.2
Economic Data of the Legal Amazon, 2021

	Population		Area		Density	
	Inhabitants	(%) of Brasil	Km²	(%) of Brasil	Hab./km²	(%) of Brasil
Brazil	9.012,142	100,0%	213.317.639	100,0%	42.247,52	100,0%
Legal Amazon	**910,280**	**10,1%**	**28.419.712**	**13,3%**	**32.029,88**	**75,8%**
Regions						
Western	229,278	2,5%	7.644.862	3,6%	29.991,14	71,0%
Eastern	681,002	7,6%	20.774.850	9,7%	32.780,11	77,6%
States						
Rondônia	58,170	0,6%	1.815.278	0,9%	32.044,73	75,8%
Acre	21,374	0,2%	906.876	0,4%	23.569,31	55,8%
Amazonas	131,531	1,5%	4.269.995	2,0%	30.803,56	72,9%
Roraima	18,203	0,2%	652.713	0,3%	27.887,57	66,0%
Pará	262,905	2,9%	8.777.124	4,1%	29.953,43	70,9%
Amapá	20,100	0,2%	877.613	0,4%	22.902,86	54,2%
Tocantins	51,781	0,6%	1.607.363	0,8%	32.214,73	76,3%
Maranhão	112,826	1,3%	5.945.516	2,8%	18.976,66	44,9%
Mato Grosso	233,390	2,6%	3.567.234	1,7%	65.426,10	154,9%

Source: IBGE. Prepared by: Ex Ante Consultoria Econômica

West meridian (**Map 1.1**). This meridian cuts across Maranhão from north to south, creating a group of 21 municipalities whose territory lies partly within the Legal Amazon and partly outside it. On average, 43.2% of the area of these municipalities belongs to the Legal Amazon.

The territorial extension is just over 5 million km², which corresponds to almost 60% of the Brazilian territory (Table 1.1). In total, there are 772 municipalities grouped into 2 regions: Western and Eastern. The Western Legal Amazon includes the states of Amazonas, Acre, Rondônia, and Roraima, while the Eastern Legal Amazon is composed of the remaining states: Amapá, Maranhão, Mato Grosso, Pará, and Tocantins. According to IBGE data, the municipalities of the Legal Amazon had 26.651 million inhabitants in 2022, which corresponded to only 13.1% of the Brazilian population. Thus, it is a region with low population density compared to the country as a whole. In 2022, the Legal Amazon had 5.30 inhabitants per km², which corresponded to 22.2% of the national average of 23.86 inhabitants per km². Among these municipalities, only those located in Maranhão approach the national population density. **Map 1.2** shows the spatial distribution of population density in the municipalities of the Legal Amazon in 2022.

The GDP of these 772 municipalities totaled BRL 910.3 billion in 2021, which represented only 10.1% of all income generated in Brazil that year. Most of this income is generated in the Eastern region of the Legal Amazon, which also concentrates a larger share of the population (**Table 1.2**). The average per capita GDP of the municipalities of the Legal Amazon was BRL 32,030 per year, a value lower than the national average, which reached BRL 42,248 in 2021. **Map 1.3** shows the regional distribution of per capita GDP in the municipalities of the Legal Amazon. Darker colors represent higher per capita GDP values.

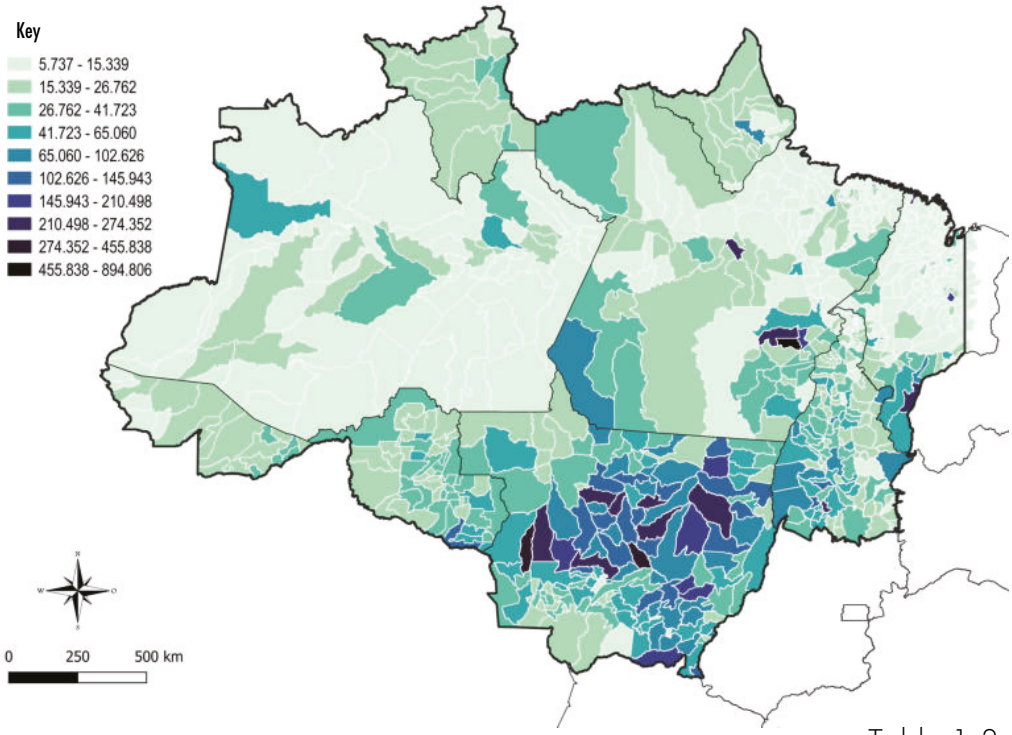
Other indicators that highlight the economic importance of these municipalities are their share in the number of Brazilian companies, in job creation, and in sustaining labor income. Data from IBGE's National Business Register indicate that only 6.6% of Brazilian companies are headquartered or operate in these 772 municipalities. These activities generated 4.456 million jobs in 2022, which corresponded to 8.1% of all jobs in Brazil, excluding public servants. These jobs accounted for a payroll of BRL 148.863 billion in that year, or 7.5% of the salaries paid by the private sector in the country.

Since the share of total employees in Brazil was greater than the share of payroll, the Legal Amazon ended up showing an average annual salary 7.4% lower than Brazil as a whole. However, this difference is relatively small when compared with the per capita GDP gap of -24.2%. **Map 1.4** shows the spatial distribution of average salaries in the region. Darker colors represent higher average salary values.

1.3. ANALYSIS OUTLINE

Chapter 2 of the report describes the demographic situation and the evolution of sanitation in the 772 municipalities of the Legal Amazon from 2000 to 2022. This analysis identifies the populations with and without access to sanitation services in the region. **Chapter 3** of the study presents estimates of the employment and income generation effects resulting from investments in

Map 1.3
GDP per Capita of the Municipalities of the Legal Amazon, in BRL thousand per year, 2021



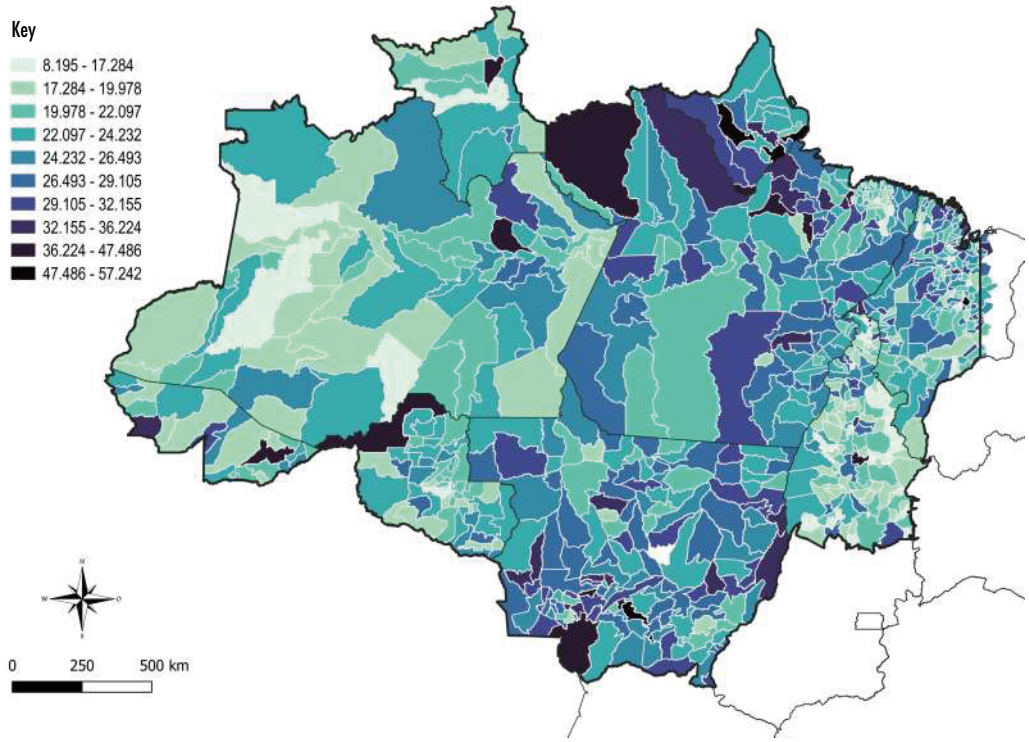
Source: IBGE.
Prepared by: Ex Ante Consultoria Econômica.

Table 1.3
Productive Activities of the Legal Amazon, 2022

	Companies		Jobs		Salaries	
	Number	(%) of Brazil	People	(%) of Brazil	BRL billion	(%) of Brazil
Brazil	5.748.599	100,0%	55.296.012	100,0%	1.994,86	100,0%
Legal Amazon	**381.101**	**6,6%**	**4.455.549**	**8,1%**	**148,863**	**7,5%**
Regions						
Western	87.908	1,5%	1.251.045	2,3%	43,240	2,2%
Eastern	293.193	5,1%	3.204.504	5,8%	105,624	5,3%
States						
Rondônia	35.443	0,6%	343.396	0,6%	10,200	0,5%
Acre	9.018	0,2%	137.337	0,2%	5,168	0,3%
Amazonas	36.478	0,6%	665.502	1,2%	24,080	1,2%
Roraima	6.969	0,1%	104.810	0,2%	3,792	0,2%
Pará	82.715	1,4%	1.148.178	2,1%	36,828	1,8%
Amapá	7.415	0,1%	124.381	0,2%	5,618	0,3%
Tocantins	31.481	0,5%	298.643	0,5%	10,045	0,5%
Maranhão	61.895	1,1%	750.761	1,4%	22,298	1,1%
Mato Grosso	109.687	1,9%	882.541	1,6%	30,835	1,5%

Source: IBGE. Prepared by: Ex Ante Consultoria Econômica

Map 1.4
Average Salaries in the Municipalities of the Legal Amazon, in BRL thousand per year, 2022



Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

the expansion of the sanitation system and from the subsequent operation of the newly installed infrastructure.

The analysis is based on data from 2005 to 2022 from SNIS (Ministry of Cities), the Annual Survey of the Construction Industry (IBGE), and the Annual Survey of Services (IBGE).

Next, **Chapters 4** and **5** analyze the indirect effects of sanitation progress, which include the impacts on health, labor productivity, and environmental enhancement. Finally, the cost-benefit balances of sanitation progress from 2005 to 2023 in the Legal Amazon, as well as the universal access to sanitation through 2040 in all 772 municipalities, are analyzed. The economic legacy of this social achievement for future generations of the Legal Amazon is also presented.

The bibliography and the detailed description of the statistical, mathematical, and accounting methodologies employed in this study are provided in the Annexes at the end of the publication.

PART 1

SANITATION ACTIVITIES IN THE LEGAL AMAZON AND THE GENERATION OF EMPLOYMENT AND INCOME

2

EVOLUTION OF SANITATION IN THE LEGAL AMAZON FROM 2000 TO 2022

According to information from the 2022 Demographic Census, 68.4% of the population of the 772 municipalities of the Legal Amazon had access to water supply, and only 23.2% had access to sewage collection in their homes, including households with septic tanks connected to the general sewage collection network. As illustrated in **Chart 2.1**, this reflects the slow progress observed since 2000. During this period, just over 8.055 million people gained access to treated water supply services, and 4.133 million people gained access to sewage collection services in their homes.

Maps 2.1 and **2.2** show, respectively, the percentage of the population in each of the 772 municipalities of the Legal Amazon that had access to treated water and sewage collection services in their homes. Darker colors represent municipalities with the highest percentages of access to basic sanitation services. It is worth noting that, in terms of access to treated water, there is a large group of municipalities with high percentages of their population having access to this service. On the other hand, **Map 2.2** shows that the vast majority of municipalities in the Legal Amazon still had low coverage of access to sewage collection services in 2022.

Furthermore, the percentage of the population living in households without a bathroom fell from 3.577 million in 2000 to 414 thousand in 2022. In relative terms, the bathroom deficit that affected 18.0% of the Legal Amazon's population in 2000 fell to 1.6% in 2022, indicating significant progress in this area, which is the most concerning of all.

The expansion of sanitation services is reflected in the network extension data shown in **Chart 2.3**. In 2005, the water distribution network in these municipalities totaled 18,262 kilometers, an extension that increased to 88,587 kilometers in 2022. The growth rate was 9.7% per year over these 17 years. The sewage collection network, in turn, expanded from 2,368 kilometers in 2005 to 17,626 kilometers in 2022, showing an annual growth rate of 12.5%.

Chart 2.1
Population Served by Water and Sewage, Legal Amazon, (%) of Total Population

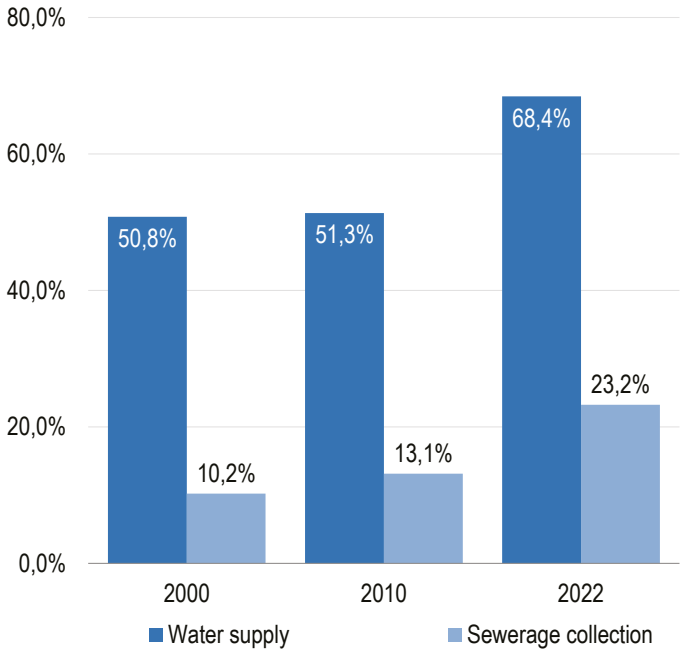
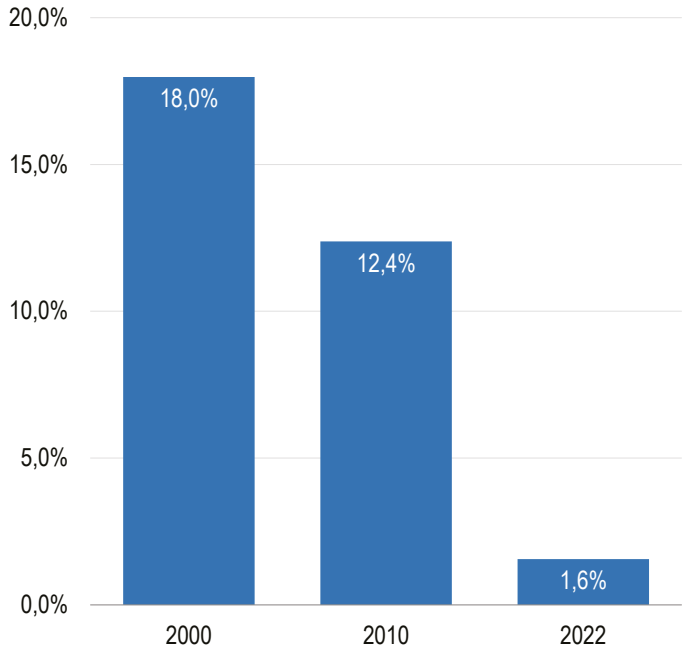


Chart 2.2
Population Without a Private Bathroom in Households, Legal Amazon, (%) of Total Population



Source: SNIS. Prepared by: Ex Ante Consultoria Econômica.

Chart 2.3
Extension of Water and Sewage Networks, Legal Amazon, in Kilometers

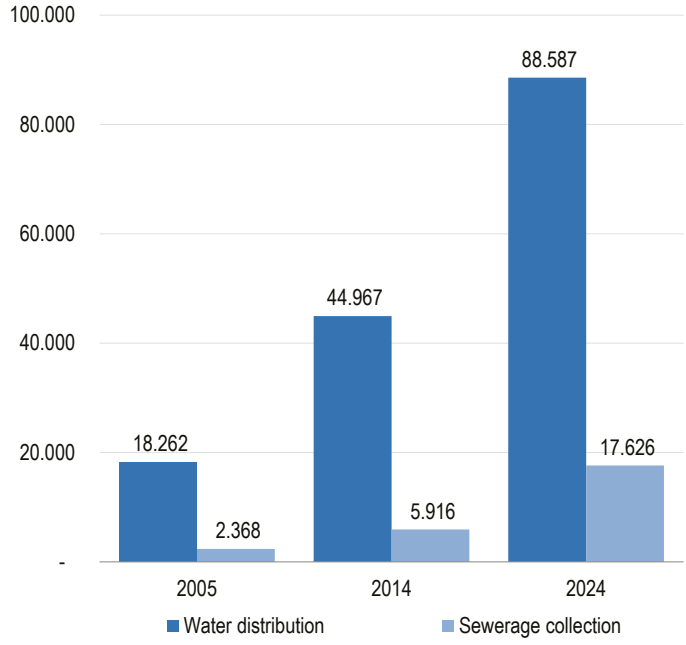
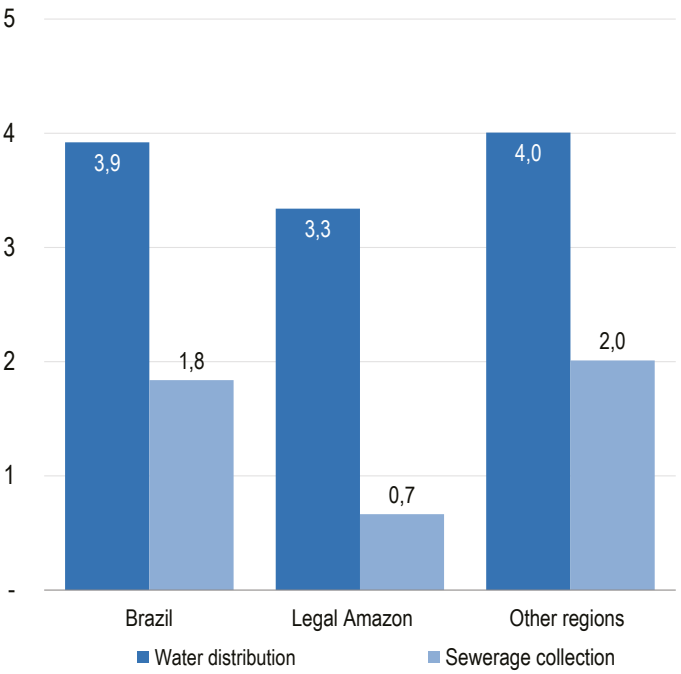
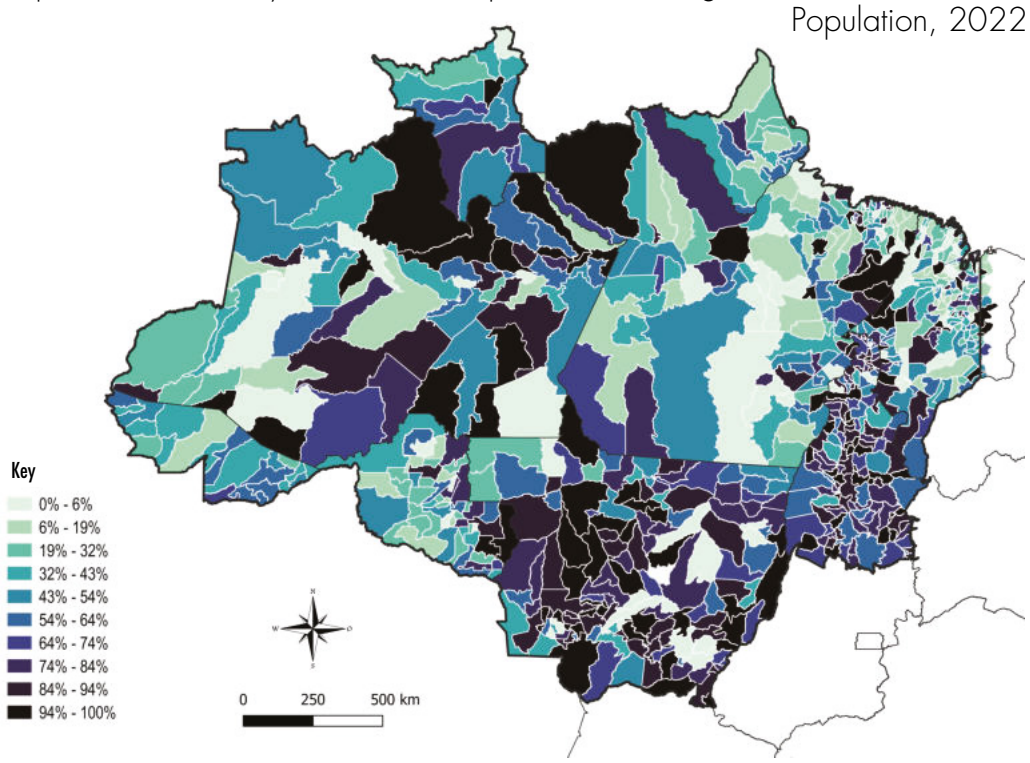


Chart 2.4
Extension of Water and Sewage Networks, in Meters per Capita, 2022



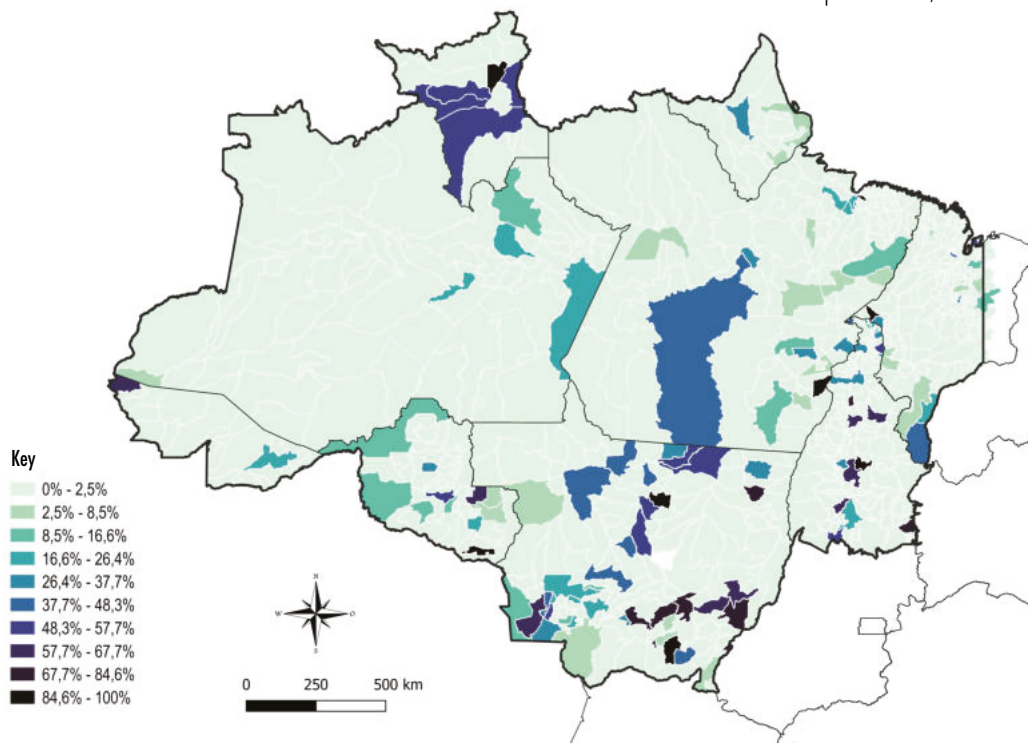
Source: SNIS. Prepared by: Ex Ante Consultoria Econômica.

Map 2.1
Population Served by Water, Municipalities of the Legal Amazon, (%) of Total Population, 2022



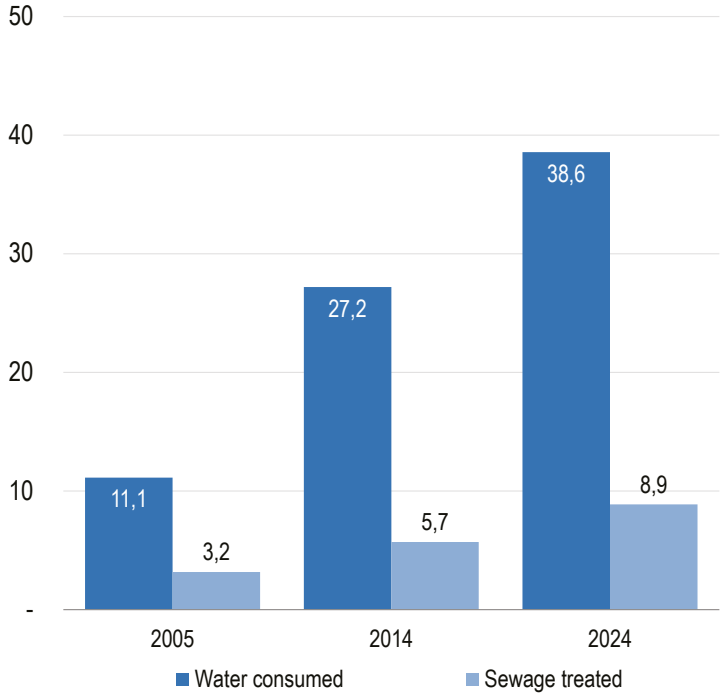
Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

Map 2.2
Population Served by Sewage Collection, Municipalities of the Legal Amazon, (%) of Total Population, 2022



Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

Chart 2.5
Water Consumption and Volume of Treated Sewage, Legal Amazon, m³ per Inhabitant per Year



Source: SNIS. Prepared by: Ex Ante Consultoria Econômica.

These increases were the result of the investments made during those years, a topic that will be analyzed in the following section of this study. Despite this strong progress, the lengths of water supply networks per inhabitant and sewage collection networks per inhabitant in the Legal Amazon are smaller than the national average, as illustrated in **Chart 2.4**.

During this period, the volume of water consumed increased from 221.2 million m³ in 2005 to 1.023 billion m³ in 2022, which corresponds to an annual growth rate of 9.4%. On a per capita basis, the volume of water consumed rose from 11.120 m³ per inhabitant to 38.565 m³ per inhabitant over this period, as illustrated in Chart 2.5. Per capita consumption grew 7.6% over these 17 years.

The volume of sewage collected, in turn, increased from 62.971 million m³ in 2005 to 235.203 million m³ in 2022, indicating an annual growth rate of 8.1% during the period. The per capita volume of sewage collected rose from 3.166 m³ in 2005 to 8.865 m³ in 2022. The treatment of collected sewage grew from 21.996 million m³ in 2005 to 171.754 million m³ in 2022, indicating an annual growth rate of 12.9% during the period.

Table 2.1 shows the situation of basic sanitation in Brazil and in the Legal Amazon. In 2022, 32.038 million people were still living in households without access to treated water in Brazil. Of this total, 29.6% lived in the 772 municipalities of the Legal Amazon, which represented a population of 9.479 million people. This means that the relative deficit in water supply was still nearly 35.6% of the population in this region, a rate higher than the national average of 15.8%.

Table 2.1
Population with Access and Sanitation Deficit, in People and (%), 2022

	Population	Population with access to				Relative sanitation deficit	
		Treated water	Sewerage collection	Treated water	Sewerage collection	Treated water	Sewerage collection
Brazil	203.080.756	171.042.954	112.803.960	32.037.802	90.276.796	15,8%	44,5%
Legal Amazon	**26.650.798**	**17.171.738**	**4.680.105**	**9.479.060**	**21.970.693**	**35,6%**	**82,4%**
Regions							
Western	6.989.534	4.924.322	1.205.852	2.065.212	5.783.682	29,5%	82,7%
Eastern	19.661.264	12.247.416	3.474.253	7.413.848	16.187.011	37,7%	82,3%
States							
Rondônia	1.581.196	884.665	140.571	696.531	1.440.625	44,1%	91,1%
Acre	830.018	398.459	87.383	431.559	742.635	52,0%	89,5%
Amazonas	3.941.613	3.135.662	560.592	805.951	3.381.021	20,4%	85,8%
Roraima	636.707	505.536	417.306	131.171	219.401	20,6%	34,5%
Pará	8.121.025	4.284.161	703.170	3.836.864	7.417.855	47,2%	91,3%
Amapá	733.759	344.360	39.508	389.399	694.251	53,1%	94,6%
Tocantins	1.511.460	1.285.272	529.340	226.188	982.120	15,0%	65,0%
Maranhão	5.636.371	3.265.444	781.214	2.370.927	4.855.157	42,1%	86,1%
Mato Grosso	3.658.649	3.068.179	1.421.021	590.470	2.237.628	16,1%	61,2%

Source: SNIS. Prepared by: Ex Ante Consultoria Econômica.

Table 2.2
Water Consumption and Sewage Collection and Treatment, in 1,000 m^3, 2022

	Volume of water consumed (A)	Sewage volume		Treated sewage in relation to		Sanitation deficit	
		Collected (B)	Treated (C)	Sewage collected (C/B)	Water consumed (C/A)	Collection (1-B/A)	Treatment (1-C/A)
Brazil	11.630.331	6.106.423	4.956.581	81,2%	42,6%	47,5%	57,4%
Legal Amazon	**1.023.222**	**235.203**	**171.754**	**0,0%**	**16,8%**	**77,0%**	**83,2%**
Regions							
Western	271.390	59.591	49.696	83,4%	18,3%	78,0%	81,7%
Eastern	751.832	175.611	122.059	69,5%	16,2%	76,6%	83,8%
States							
Rondônia	45.638	5.073	4.089	80,6%	9,0%	88,9%	91,0%
Acre	22.570	7.479	644	8,6%	2,9%	66,9%	97,1%
Amazonas	176.745	23.724	21.968	92,6%	12,4%	86,6%	87,6%
Roraima	26.437	23.316	22.995	98,6%	87,0%	11,8%	13,0%
Pará	273.028	25.573	17.068	66,7%	6,3%	90,6%	93,7%
Amapá	17.572	2.571	2.493	97,0%	14,2%	85,4%	85,8%
Tocantins	69.928	20.872	20.780	99,6%	29,7%	70,2%	70,3%
Maranhão	192.805	52.781	21.916	41,5%	11,4%	72,6%	88,6%
Mato Grosso	198.499	73.815	59.803	81,0%	30,1%	62,8%	69,9%

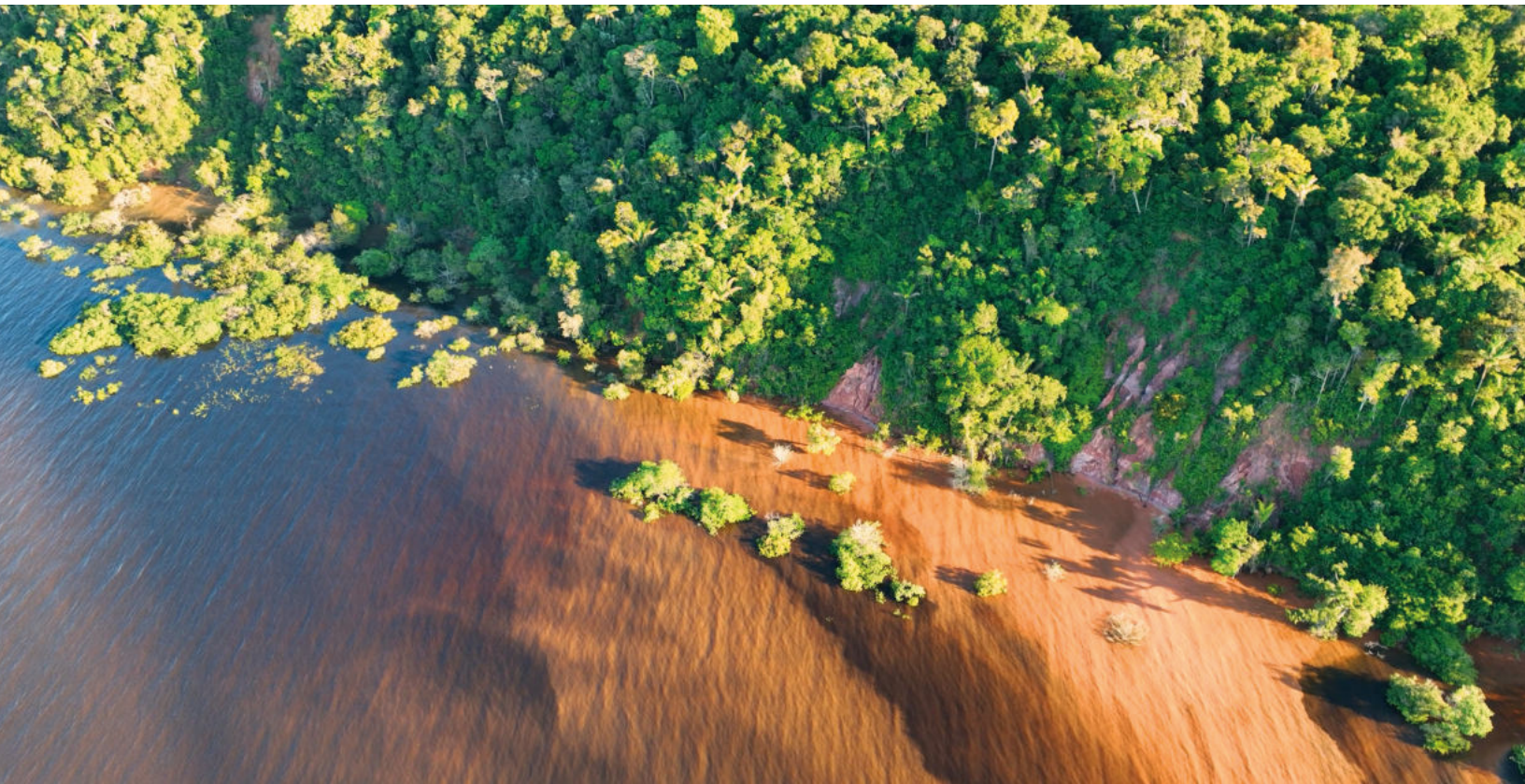
Source: SNIS. Prepared by: Ex Ante Consultoria Econômica.

Among the states that make up the Legal Amazon, five had relative deficits greater than 40% of the population; in Acre and Amapá, the deficits exceeded 50%.

In the case of access to sewage collection, the number was even higher: 90.277 million inhabitants were still living in households without sewage collection in Brazil in 2022. Again, a large share of this population without access to the system lived in the 772 municipalities of the Legal Amazon. In total, 21.971 million people had no sewage collection in their homes. In relative terms, this indicates that 82.4% of the population of these 772 municipalities was not connected to the general sewage collection network, a rate much higher than the national average. Excluding households located in rural areas or isolated urban areas, where sewage is usually disposed of without collection or treatment, such as in septic tanks, the majority of human waste and water used by this population returned untreated to the environment, heavily affecting not only the environment of the region itself but also the downstream municipalities along the river basins.

However, the greatest problem in the sanitation system of the Legal Amazon was the lack of sewage treatment (**Table 2.2**). In 2022, only 17.6% of the state's population lived in homes with sewage collection, and of the total sewage generated, only 16.8% received treatment before returning to the environment. Thus, a simple sewage disposal system prevailed in the region. As a result, the sewage treatment deficit reached 83.2% in 2022.

Across the 772 municipalities, the treatment deficit was even higher: 82.4% of the sewage generated was discharged without treatment. The environmental impact is therefore immense and even greater than revealed by the sewage collection data. The river basins of the region receive an estimated load of about 851.5 million m^3 per year of untreated residential sewage. Every day, 2.333 trillion liters of dirty water are dumped into the streams and rivers that run through the Legal Amazon!



3

INCOME AND EMPLOYMENT GENERATION IN SANITATION EXPANSION

This chapter addresses the economic gains arising from investments and from the expansion of sanitation operations in the Legal Amazon. First, it presents the classification of the effects on employment and income. Next, statistics on the evolution of investments and revenues from sanitation operations are presented, which serve to estimate the levels of employment and income supported: (i) by the works carried out between 2005 and 2022, and (ii) by the operations of water treatment and distribution and sewage collection and treatment in the serviced area. The methodology used to measure these effects is described in detail in the Methodological Annex.

3.1. CLASSIFICATION OF EFFECTS

The expansion of sanitation involves substantial investments in civil construction, which have significant economic effects in the areas where the works are carried out and during the period of their execution. The installation of a sanitation system in a city includes construction works for water distribution networks, sewage collection networks, water intake and treatment plants, and wastewater treatment plants.

Investments in sanitation works create jobs and expand income in the economy. Conceptually, these impacts are classified as direct, indirect, and induced. Directly, carrying out construction works requires hiring a construction company and workers, who are paid wages. This is the economic activity sustained directly by the investments made by sanitation companies or governments during the expansion or installation of services.

The construction company hired to carry out the sanitation works, in turn, purchases construction materials and contracts services from other companies. This involves payments to suppliers before and during the execution of the works. Spending on suppliers and third parties indirectly supports jobs and income in the construction supply chain.

These include, for example, jobs generated in the building materials industry or in engineering and architecture offices.

The third effect is called induced. This effect arises from the fact that, by hiring workers, whether for the construction works, the production of building materials, or support services, wages are paid. This labor income sustains workers' consumption. Their spending induces economic activity across various sectors of the economy, ranging from food production to home purchases. It is a dispersed effect but highly relevant, as wages account for a relatively large portion of the total value of sanitation works.

The direct, indirect, and induced effects of income and job generation may occur in the locations where the works are carried out or in other regions. Since the works are generally located in the city where the investments are made, the effects of these expenditures are considered local, as are the income and jobs sustained by the wages paid to employees of the construction companies performing the works.

On the other hand, employment and income in the construction supply chain (building materials and services) occur in the locations where the companies that produce these goods and services are located. For example, the cement used in a sanitation project in the South of the country may be produced in another region, just as the firm hired to perform the engineering calculations. Thus, jobs in these activities are generated in a dispersed manner across the national territory.

Once sanitation works are completed, the expansion of sanitation operations generates direct, indirect, and induced jobs. The income generated also follows this classification: there is direct income, generated and distributed within the sanitation operators; indirect income, generated in the sector's supply chain, composed of suppliers of raw materials and services to sanitation operators; and finally, induced income, sustained by the wages paid by sanitation operators to their employees and by suppliers in the chain to their workers.

The direct, indirect, and induced effects of job and income generation may occur in the locations where sanitation services are provided or in other regions. The direct effects of sanitation operations are generally local, while those generated in the sanitation supply chain occur where companies supplying inputs and services to sanitation operators are located. These companies are spread throughout the national territory, and their operations can only be measured in aggregate terms. A good example of this is the income and employment generated in the electricity sector. Sanitation companies, as is well known, are major consumers of electric power, which is used for pumping and machine operations for water treatment and distribution, as well as for sewage collection and treatment. However, this energy is generated through the grid, and it is not possible to determine whether it came from a nearby hydroelectric plant or another plant connected to the system.

3.2. EVOLUTION OF INVESTMENTS AND OPERATING REVENUES

Investment in sanitation in the 772 municipalities of the Legal Amazon increased from BRL 86.104 million in 2005 to BRL 1.479 billion in 2022, indicating an annual growth rate of 18.2%. However, this growth includes inflation in the costs of installing sanitation infrastructure. When correcting for this inflation effect, we can see that the average annual growth of sanitation investment during the period was 10.8%.

Once adjusted for inflation, BRL 18.520 billion were invested in maintenance and expansion works of water and sewage networks in the 772 municipalities between 2005 and 2022, which is

equivalent to an average of BRL 1.029 billion per year during the period – see the Methodological Annex on the method of value adjustment.

Over these 17 years, the investment per resident amounted to BRL 724,07, which corresponds to BRL 40.23 per capita per year. **Chart 3.1** shows the annual investment made in the 772 municipalities of the Legal Amazon in maintenance and expansion works of water and sewage networks in constant 2024 values.

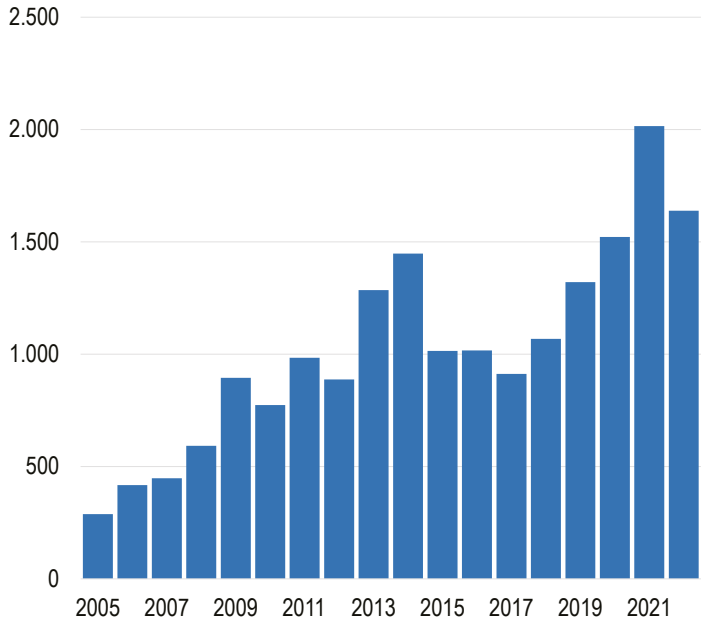
The trend in operating revenues is illustrated in **Chart 3.2,** which also presents values at constant 2024 prices – see the Methodological Annex on the method of value adjustment. On average over the period, total operating revenue was BRL 4.160 billion per year (at 2024 prices). The revenue trajectory increased throughout the period, with an average annual growth rate of 12.1% between 2005 and 2022, which resulted in a billing expansion, at constant prices, of 4.9% per year on average.

3.3. EMPLOYMENT AND INCOME GENERATION FROM INVESTMENTS

Investment in the sanitation sector in the Legal Amazon amounted to BRL 1.029 billion per year between 2005 and 2022. It is estimated that, on average over the period, these works sustained 3,966 direct jobs per year in civil construction. These jobs paid BRL 178.906 million in wages, benefits, and labor contributions (**Table 3.1**).

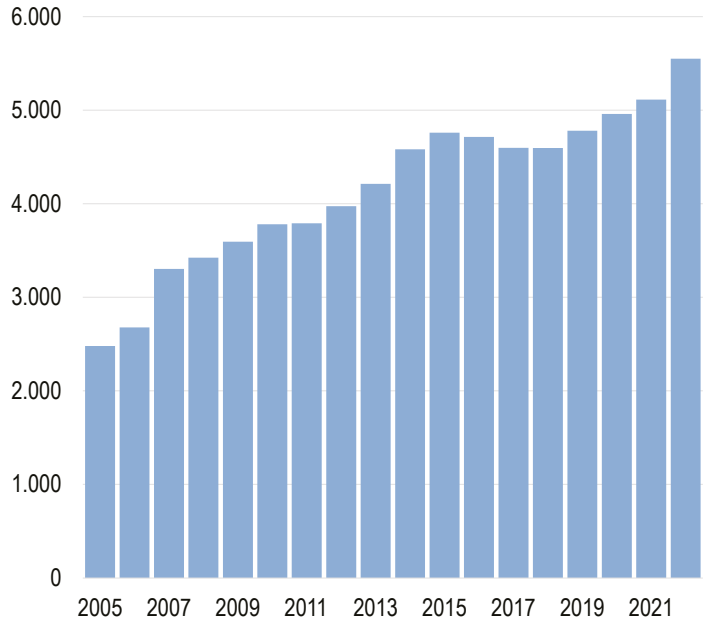
In addition to labor expenses, it is estimated that the construction companies hired to carry out the works spent BRL 584.656 million on the purchase of construction materials and services. This corresponded to 56.8% of the total investment made on average during the period.

Chart 3.1
Sanitation Investments, in BRL million, Legal Amazon, 2005 to 2022



Sources: IBGE and SINISA, Ministry of Cities. Note: (*) at 2024 constant prices. Prepared by: Ex Ante Consultoria Econômica.

Chart 3.2
Operating Revenue in Sanitation, in BRL million, Legal Amazon, 2005 to 2022



Sources: IBGE and SINISA, Ministry of Cities. Prepared by: Ex Ante Consultoria Econômica.

Table 3.1
Sanitation Investments, Direct Income and Employment, Legal Amazon, Annual Average from 2005 to 2022, BRL million* and People

	BRL million*
Sanitation Investments	1.028,900
Employed Personnel (people)	3.966
Income (GDP)	444,244
Personnel Expenses	178,906
Supplier Expenses	584,656

Sources: IBGE and SINISA, Ministry of Cities.
Note: (*) at 2024 constant prices.
Prepared by: Ex Ante Consultoria Econômica.

Table 3.2
Direct, Indirect, and Induced Income and Employment, Legal Amazon, Annual Average from 2005 to 2022, BRL million* and People

	Employment (people)	Income (BRL million*)
Direct	3.966	444,244
Indirect	1.925	314,353
Induced	3.535	450,135
Total	**9.427**	**1.208,732**

Sources: IBGE and SINISA, Ministry of Cities.
Note: (*) at 2024 constant prices.
Prepared by: Ex Ante Consultoria Econômica.

The income generated from the construction activity related to the expansion of sanitation networks in the region amounted to approximately BRL 444.244 million per year on average from 2005 to 2022. This amount is part of the region's construction sector GDP generated during this period.

Table 3.2 presents estimates of indirect and induced employment and income generated by sanitation investments, based on the methodology detailed in Methodological Annex of the report. In addition to the 3,966 direct jobs generated annually by sanitation investments in these 772 municipalities, it is estimated that 1,925 indirect jobs per year were generated in the construction supply chain on average over the period from 2005 to 2022. These jobs were generated both in the building materials industries and in construction-related service sectors, such as engineering and architectural firms. They also include companies that supply inputs to the direct suppliers of the contracted construction companies. As previously indicated, these jobs are distributed across the state and the country.

The indirect income generated by sanitation investments amounted to BRL 314.353 million per year between 2005 and 2022. This amount was lower than the expenditures on construction materials and services by the companies responsible for the works. The employment and income induced by sanitation investments, whether through wages paid by construction companies or through jobs sustained along the construction supply chain, reached approximately 3,535 people and BRL 450.135 million per year, respectively.

In total, sanitation investments supported 9,427 jobs per year nationwide and generated BRL 1.209 billion per year in income for the Brazilian economy between 2005 and 2022 (**Table 3.2**). This means that for every BRL 1.00 invested in sanitation works, BRL 1.20 in income was generated in the economy, a ratio that demonstrates the income multiplier effect of sanitation investments.

Charts 3.3 and **3.4** show the evolution of employment and income sustained by the investments made in the Legal Amazon

between 2005 and 2022. During this period, there was a steady increase in employment and income generation, peaking in 2021, when investments were significantly expanded.

3.4 EMPLOYMENT AND INCOME GENERATION FROM OPERATIONS

Between 2005 and 2022, sanitation operations in the Legal Amazon generated average operating revenues of BRL 4.160 billion per year. According to data from the National Sanitation Information System (SNIS), these operations sustained 11,104 direct jobs per year in the region. These jobs resulted in expenditures of BRL 1.341 billion on wages, benefits, and labor contributions. Of this total, about 77% was spent directly on employees and 23% on charges and social contributions.

During this period, sanitation operations in the Legal Amazon disbursed BRL 1.615 billion per year on the purchase of inputs and services required for the distribution of treated water and the collection and treatment of sewage. This corresponded to approximately 38.8% of revenues between 2005 and 2022. On average over the period, the income generated from sanitation activities reached BRL 2.545 billion per year – see **Table 3.3**.

Table 3.4 presents estimates of the indirect and induced effects of the operations carried out by the sanitation operator in the 772 municipalities of the Legal Amazon between 2005 and 2022. It is estimated that, on average over the period, 5,726 indirect jobs were generated in the sanitation supply chain. These jobs were created both in industries producing inputs for water and sewage treatment and in service sectors related to sanitation. The main one is the electricity sector, which supplies the energy for pumping and operating machines and equipment.

Chart 3.3
Jobs Generated by Sanitation Investments, Legal Amazon, People, 2005 to 2022

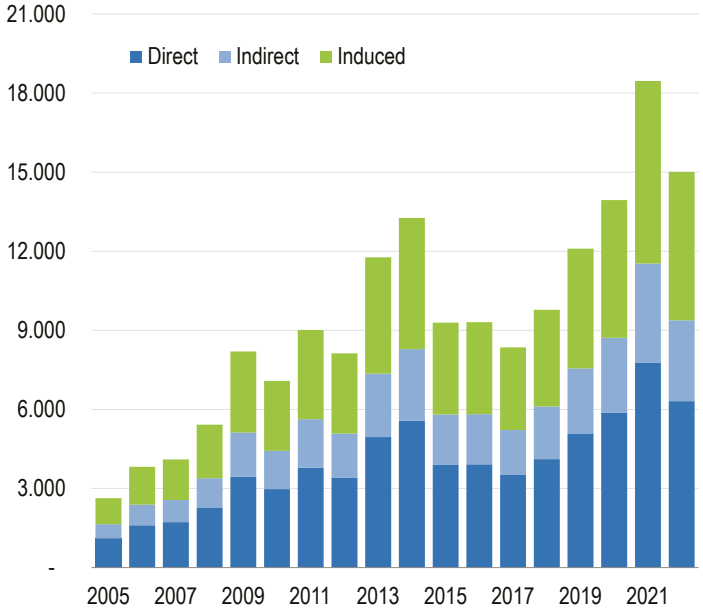
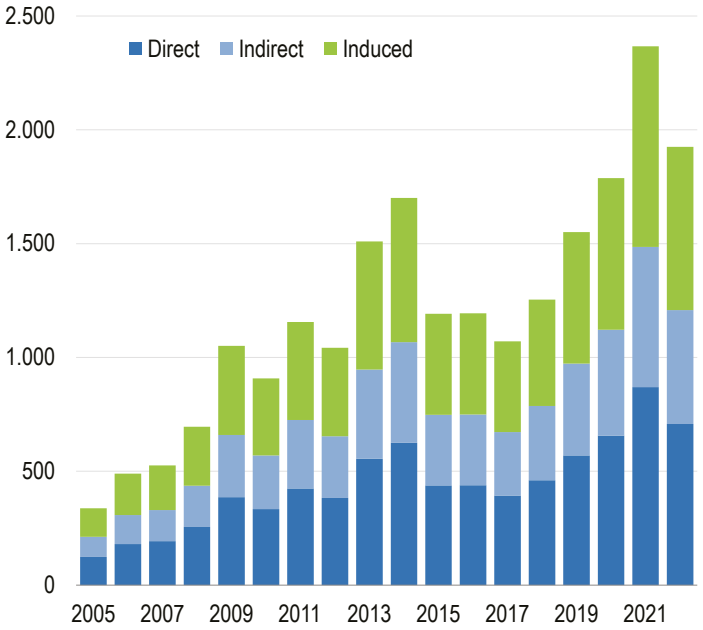


Chart 3.4
Income Generated by Sanitation Investments, Legal Amazon, BRL million*, 2005 to 2022



Sources: IBGE and SINISA, Ministry of Cities.
Note: (*) at 2024 constant prices.
Prepared by: Ex Ante Consultoria Econômica.

Table 3.3
Sanitation Operations, Direct Income and Employment, Legal Amazon, Annual Average from 2005 to 2022, BRL million* and People

	BRL million*
Total Operating Revenues	4.160,404
Employed Personnel (people)	11.104
Income (GDP)	2.545,182
Personnel Expenses	1.340,906
Supplier Expenses	1.615,222

Sources: IBGE and SINISA, Ministry of Cities. Note: (*) at 2024 constant prices. Prepared by: Ex Ante Consultoria Econômica.

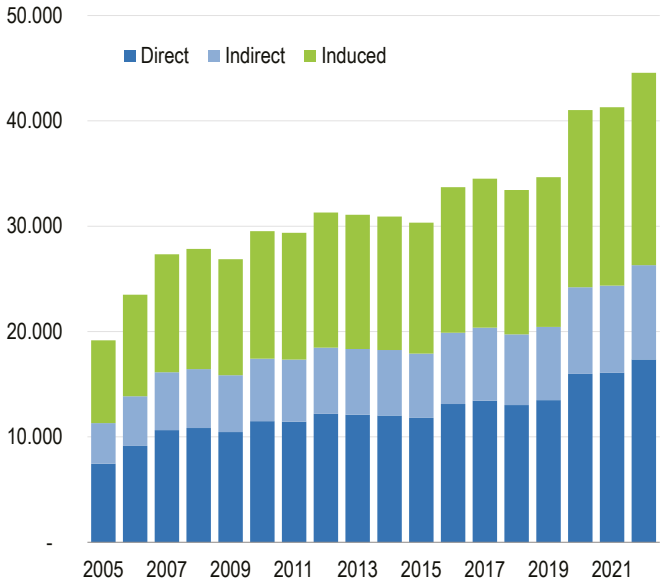
Table 3.4
Direct, Indirect, and Induced Income and Employment, Legal Amazon, Annual Average from 2005 to 2022, BRL million* and People

	Employment (people)	Income (BRL million*)
Direct	11.104	2.545,182
Indirect	5.726	1.224,441
Induced	11.690	2.839,523
Total	**28.520**	**6.609,147**

Sources: IBGE and SINISA, Ministry of Cities. Note: (*) at 2024 constant prices. Prepared by: Ex Ante Consultoria Econômica.

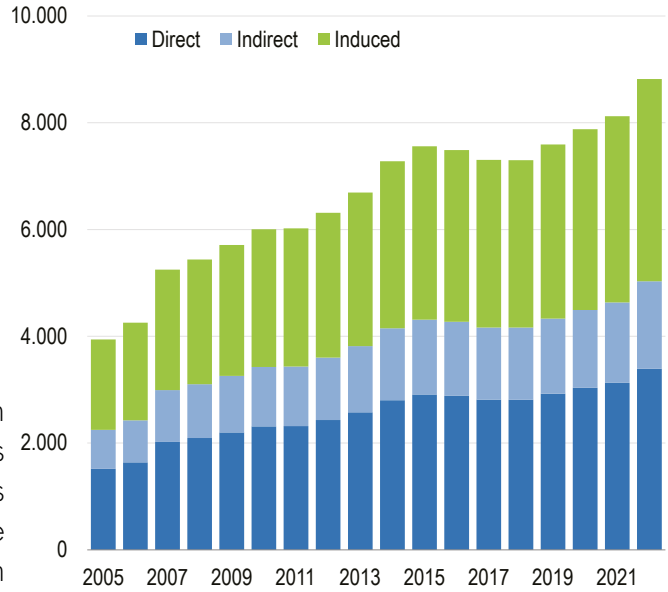
The indirect income generated in this supply chain totaled BRL 1.224 billion per year. This amount was lower than the expenditures on inputs and services required for the provision of water and sewage services by sanitation operators. As a result, the sum of direct and indirect income reached BRL 3.770 billion per year during this period.

Chart 3.5
Jobs Generated by Sanitation Operations, Legal Amazon, in Thousand People, 2005 to 2022



Sources: IBGE and SINISA, Ministry of Cities. Prepared by: Ex Ante Consultoria Econômica.

Chart 3.6
Income Generated by Sanitation Operations, Legal Amazon, BRL million*, 2005 to 2022



Sources: IBGE and SINISA, Ministry of Cities. Note: (*) at 2024 constant prices. Prepared by: Ex Ante Consultoria Econômica.

The induced income and employment reached BRL 2.840 billion and 11,690 people on average between 2005 and 2022. Thus, sanitation operations supported a total of 28,520 jobs and generated BRL 6.609 billion in income in the economy per year between 2005 and 2022, solely from sanitation activities.

The evolutions of jobs and income (including the three effects: direct, indirect, and induced) sustained by sanitation operations in the Legal Amazon are presented in **Charts 3.5** and **3.6**, respectively. An increase in the level of job and income generation has been observed in recent years, mainly driven by the rise in revenues from water distribution and sewage collection.

3.5. TAX AND CONTRIBUTION COLLECTION

A portion of the revenue from companies that built and operated the water and sewage collection networks is directly collected by public authorities in the form of taxes and contributions on production. This tax category includes ICMS, PIS, and COFINS. On average, these three taxes represented 4.6% of the gross revenue of sanitation companies, according to IBGE data from the Annual Survey of Services and the 2022 Brazilian National Accounts. For sanitation infrastructure works, the tax burden was 5.1% of the gross revenue of construction companies (Annual Survey of the Construction Industry).

Table 3.5
Taxes and Contributions Collected from Sanitation Operations and Investments, Legal Amazon, Annual Averages from 2005 to 2022

Taxes	Investments		Operations	
	BRL million	% of Gross Revenue	BRL million	% of Gross Revenue
Production-related Taxes (A)	56,197	5,5%	223,628	5,4%
ICMS	-	0,0%	11,014	0,3%
IPI	-	0,0%	-	0,0%
Import Tax	-	0,0%	-	0,0%
Other Specific Taxes	50,112	4,9%	173,978	4,2%
Other Production Taxes	6,085	0,6%	38,636	0,9%
Income and Property Taxes (B)	65,800	6,4%	458,411	11,0%
Property Tax (IPTU)	0,115	0,0%	0,874	0,0%
Vehicle Tax (IPVA)	0,041	0,0%	0,143	0,0%
Other (ITR)	-	0,0%	-	0,0%
Income Tax	16,225	1,6%	158,955	3,8%
Social Contribution on Net Profit (CSLL)	4,558	0,4%	39,636	1,0%
Social Security and FGTS	44,861	4,4%	258,802	6,2%
Total Tax Burden (A) + (B)	**121,997**	**11,9%**	**682,039**	**16,4%**

Sources: IBGE and SINISA, Ministry of Cities. Note: (*) at 2024 constant prices.
Prepared by: Ex Ante Consultoria Econômica.

The direct income generated by sanitation operations is allocated partly to the payment of wages, partly to shareholders or reinvested into the company as after-tax profit, and partly to tax payments. This group of taxes includes income and property taxes: Property Tax (IPTU), Vehicle Tax (IPVA), Corporate Income Tax, Social Contribution on Net Profit (CSLL), Employer Social Security Contribution, and the Severance Indemnity Fund (FGTS). This set of taxes represented 10.3% of the gross revenue of sanitation companies in Brazil, according to IBGE data, resulting in a total tax burden of 14.8% of gross revenue. In the case of construction, income and property taxes accounted for 6.1% of gross revenue, resulting in a total tax burden of 11.3%.

By applying these percentages to the gross sanitation revenue in the Legal Amazon, tax collection is estimated at BRL 682.039 million per year on average for the period from 2005 to 2022. From the amounts invested, it is estimated that BRL 121.997 million was collected per year. **Table 3.5** presents the distribution of these amounts among the taxes and contributions. These amounts were distributed among the three levels of government according to legal designations.

PART 2

BENEFITS OF UNIVERSAL SANITATION ACCESS

4

SANITATION AND HEALTH

The lack of sanitation has immediate implications for the health and quality of life of populations living in environmentally degraded areas. The absence of treated water has a direct impact on health, especially for the very young and the elderly, as it increases the incidence of waterborne and respiratory diseases. The lack of sewage collection and treatment services, even when treated water is available, also significantly affects the incidence of gastrointestinal infections and diseases transmitted by mosquitoes and animals.

The most serious problems arise along the banks of contaminated rivers and streams or on streets where sewage runs in the open – in ditches, gutters, streams, or rivers. But it is also present in the pollution of water reservoirs and water sources whose quality has deteriorated over the years. Environmental exposure to sewage and the lack of treated water cause illnesses that harm the health of children, youth, and adults.

The recurrence of these diseases harms society by generating irreversible costs. There are two immediate channels linking the lack of sanitation to these costs:

i. By increasing the incidence of these diseases, the lack of sanitation leads to people being absent from their jobs, resulting in costs to society due to lost working hours; and

ii. Society incurs public and private expenses for the treatment of infected individuals.

This chapter analyzes the externalities of sanitation on population health. The analyses focus on national data and data from the Legal Amazon, allowing for the assessment of differences between indicators that may be associated with sanitation. This contrast makes it possible, on the one hand, to evaluate the gains already achieved with the progress of sanitation and, on the other, to estimate the legacy of universal access to basic sanitation.

4.1. WATERBORNE DISEASES

Based on data from the 2019 National Health Survey (IBGE, 2020), it is possible to estimate the number of absences from routine activities due to waterborne diseases[1]1. The survey asked a representative sample of the Brazilian population whether they had been absent from their routine activities during the two weeks prior to the interview date, the reason for the absences, and how many days they were absent.

In 2019, 1.688 million Brazilians reported having been absent from their activities during the two weeks prior to the interview due to the occurrence of waterborne diseases. Based on these data, it is estimated that there were a total of 43.374 million cases of absence due to these diseases throughout Brazil in 2019. In the Amazon, there were 4.315 million cases, or 9.9% of the national total.

These reports of absence indicate an incidence rate of 206.9 cases per 1,000 inhabitants throughout 2019 in Brazil. The Legal Amazon recorded a slightly lower incidence of 204.4 cases per thousand inhabitants. This incidence rate was higher in the rest of the country, as illustrated in **Chart 4.1** (207.2 cases per thousand inhabitants).

A portion of those who were absent due to waterborne diseases ended up bedridden due to the severity of the illness. **Chart 4.1** also shows the incidence rate of bedridden individuals due to waterborne diseases. In Brazil, there were 84.8 bedridden cases per thousand inhabitants, while in the Legal Amazon there were 101.2 cases per thousand inhabitants. On average, in the other regions of the country, the incidence was 83.0 cases per thousand inhabitants.

Chart 4.2 presents the incidence rate of absences due to diarrhea or vomiting and the incidence rate of bedridden individuals from these illnesses, by age group, in cases per thousand inhabitants during 2019 in the Legal Amazon. Throughout 2019, the incidence of absences was higher among children and adolescents, while the incidence of bedridden individuals was higher among the elderly. For all age groups, the incidence rates of absences were higher than those of bedridden cases.

Based on microdata from the 2019 National Health Survey (IBGE, 2020), which provides a wide range of information on individuals, their households, and the occurrence (or not) of absences, it was found that **the probability of being absent from daily activities due to diarrhea or vomiting was negatively correlated with access to sewage collection and treated water services**. The greater the access to these services, the lower the likelihood of absence due to waterborne diseases – see details in Methodological Annex 2.

The 2019 National Health Survey (IBGE, 2020) indicated that individuals who were absent remained away from their activities for an average of nearly 4.6 days in the country. In the 772 municipalities of the Legal Amazon, people were absent for a period well above the national average: 4.8 days per absence. The incidence and duration of absences resulted in 20.537 million days away from routine activities over the course of a year in the Legal Amazon. If they had not contracted gastrointestinal infections, these individuals could have worked, studied, or simply rested during the period they were ill.

[1] The waterborne diseases considered in the 2019 National Health Survey include: gastrointestinal problems (diarrhea, vomiting, nausea, gastritis, and stomach ache) and infections transmitted by mosquitoes such as dengue, chikungunya, Zika virus, or yellow fever.

Based on information from the Unified Health System, there were 273,000 hospitalizations due to waterborne2 diseases throughout 2019 in Brazil, of which 85,100 were in the Legal Amazon. The incidence of hospitalizations in the 772 municipalities that make up the region was 2.937 cases per thousand inhabitants in 2019, a rate higher than that of the other regions of the country, which reached 1.039 cases per thousand inhabitants.

With regard to the 772 municipalities of the Legal Amazon, it is worth noting that the incidence rate is much higher among children (5.739 cases per thousand inhabitants) – see **Chart 4.4**. Among the elderly, the incidence is also relatively high: 3.413 cases per thousand inhabitants.

4.2. RESPIRATORY DISEASES

In addition to waterborne diseases, the lack of sanitation affects the incidence of respiratory diseases. The most direct link between lack of sanitation and respiratory diseases lies in access to hand hygiene. Ryan et al. (2001) analyzed the effect of training on handwashing habits on the incidence of respiratory diseases in U.S. military personnel undergoing training between 1996 and 1998. The group that received training and had unrestricted access to water and hygiene products had an incidence rate 45% lower than the group without training or without access to water and hygiene materials. Rabie and Curtis

[2] Waterborne diseases include: cholera, typhoid and paratyphoid fevers, shigellosis, amebiasis, diarrhea and gastroenteritis of presumed infectious origin, other intestinal infectious diseases, icterohemorrhagic leptospirosis, other forms of leptospirosis, unspecified leptospirosis, yellow fever, dengue, dengue hemorrhagic fever, malaria caused by Plasmodium falciparum, malaria caused by Plasmodium vivax, malaria caused by Plasmodium malariae, other forms of malaria confirmed by parasitological tests, unspecified malaria, and schistosomiasis.

Chart 4.1
Absences and Bedridden Cases due to Waterborne Diseases, Cases per Thousand Inhabitants, by Region, 2019

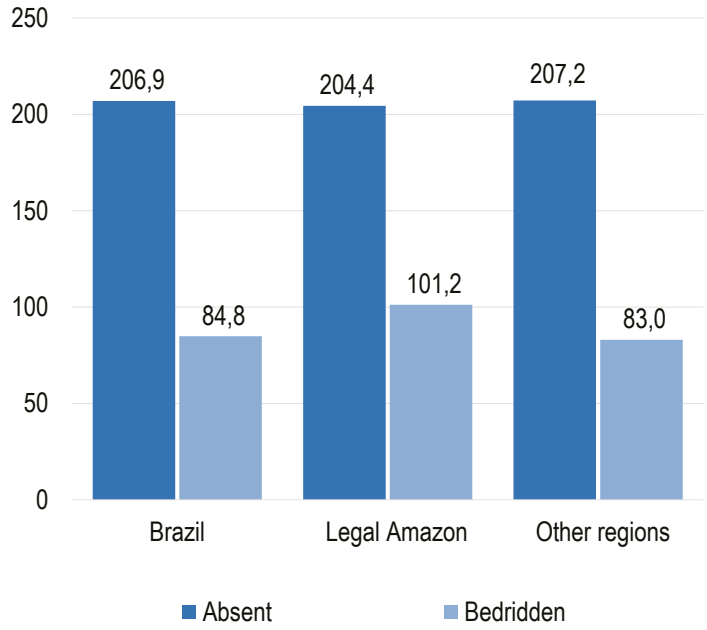
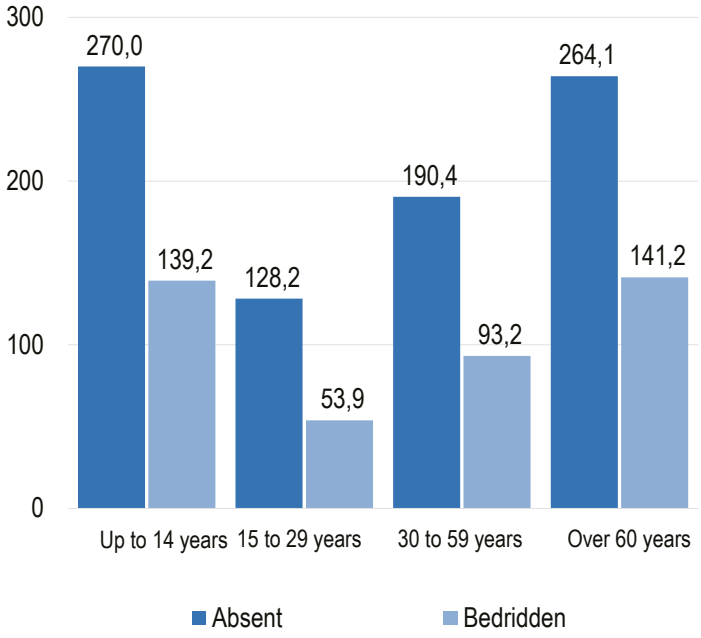
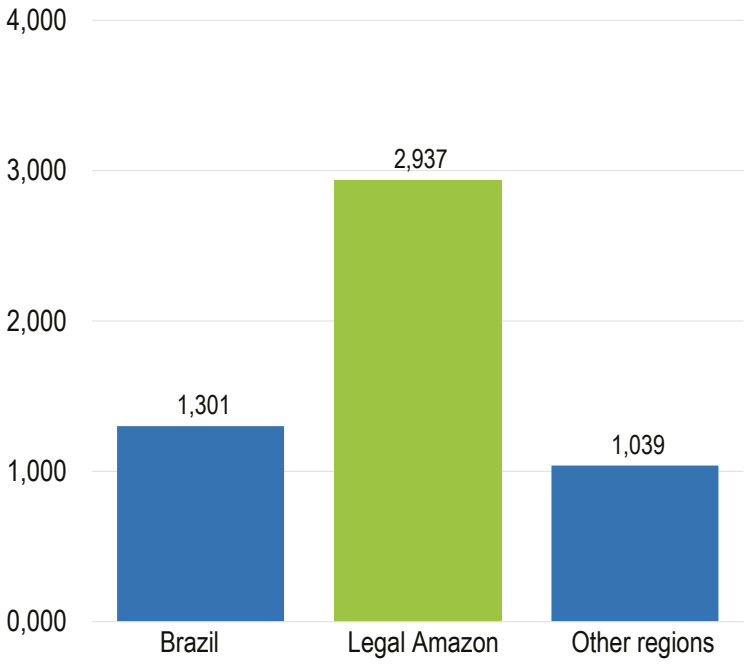


Chart 4.2
Absences and Bedridden Cases due to Waterborne Diseases, Cases per Thousand Inhabitants, by Age Group, Legal Amazon Average, 2019



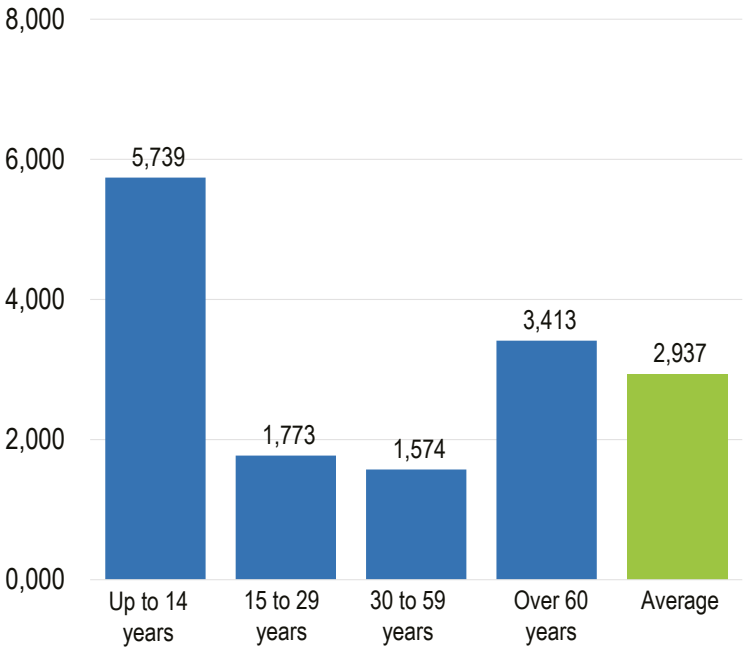
Source: IBGE (2020). Prepared by: Ex Ante Consultoria Econômica.

Chart 4.3
Hospitalizations due to Waterborne Diseases, Cases per Thousand Inhabitants, 2019



Source: Datasus and IBGE. Prepared by: Ex Ante Consultoria Econômica.

Chart 4.4
Hospitalizations due to Waterborne Diseases, Cases per Thousand Inhabitants, by Age Group, Legal Amazon Average, 2019



Source: Datasus and IBGE. Prepared by: Ex Ante Consultoria Econômica.

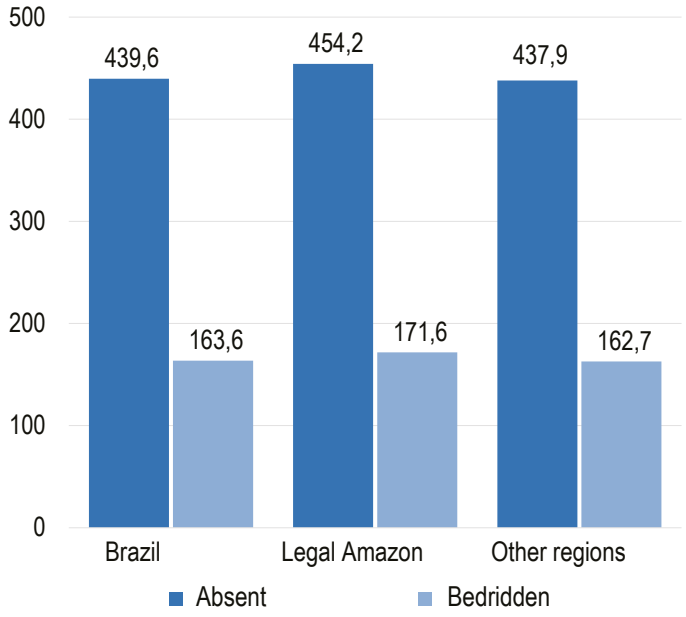
(2006) provide an extensive review of studies with diverse populations published up to 2004. These studies concluded that handwashing reduced the incidence of respiratory diseases by between 6% and 44%.

Based also on data from the 2019 National Health Survey (IBGE, 2020), it is possible to estimate the number of absences from routine activities due to respiratory diseases – flu, pneumonia, bronchitis, and asthma – in Brazil. It is estimated that there were a total of 92.130 million cases of absence due to respiratory diseases in the country throughout 2019, a volume 2.12 times higher than the number of absences caused by waterborne diseases. These reports of absence indicate an incidence rate of 439.6 cases per 1,000 inhabitants throughout 2019 in Brazil. In the Legal Amazon, the incidence of absences was higher: 454.2 cases per thousand people, exceeding the incidence rate in the rest of the country (437.9 cases per thousand inhabitants) (**Chart 4.5**).

A portion of those absent due to respiratory diseases became bedridden due to the severity of the illness. **Chart 4.5** also shows the incidence rate of bedridden individuals due to respiratory diseases. In Brazil, there were 163.6 cases per thousand inhabitants, while in the Legal Amazon there were 171.6 cases per thousand inhabitants. The rest of the country showed a lower incidence of bedridden cases than the Legal Amazon: 162.7 cases per 1,000 inhabitants.

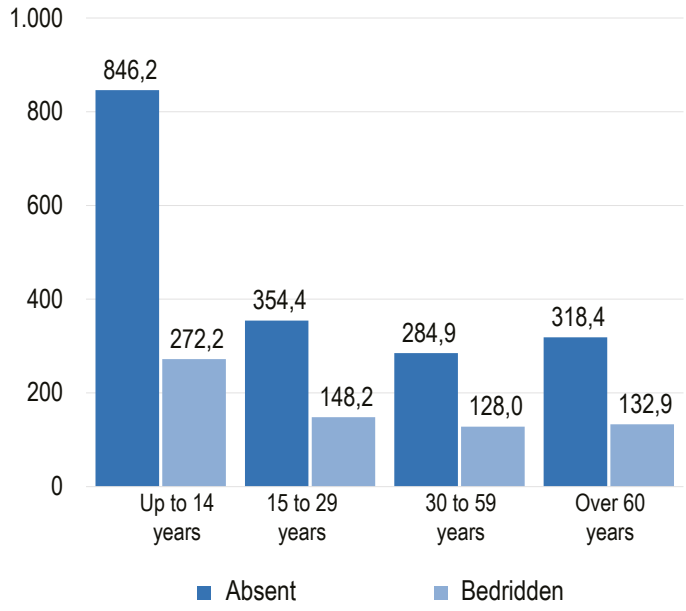
Chart 4.6 presents the incidence rate of absences and bedridden cases due to respiratory diseases by age group. The statistics are in cases per thousand inhabitants throughout 2019 and refer to the group of 772 municipalities in the Legal Amazon. Throughout 2019, the incidence of absences was very high among children (846.2 cases per thousand inhabitants), with the incidence of bedridden cases also higher among young people: 272.2 cases per 1,000 inhabitants.

Chart 4.5
Absences and Bedridden Cases due to Respiratory Diseases, Cases per Thousand Inhabitants, 2019



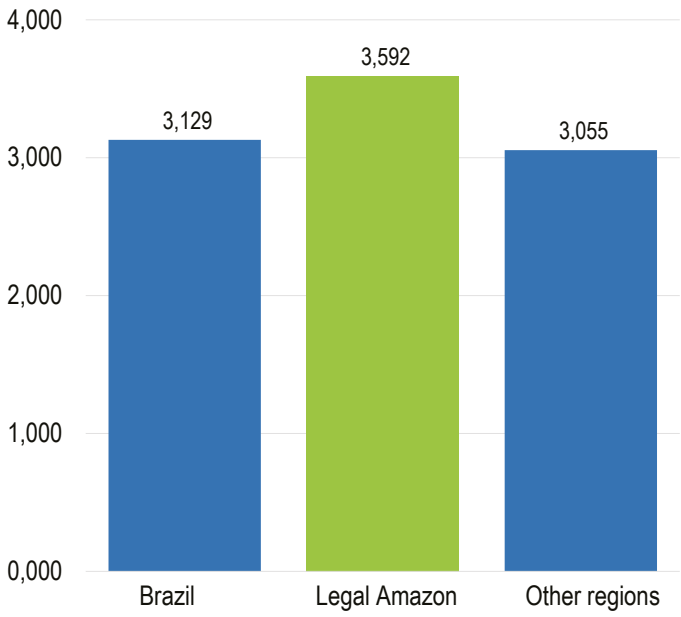
Source: Datasus and IBGE. Prepared by: Ex Ante Consultoria Econômica.

Chart 4.6
Absences and Bedridden Cases due to Respiratory Diseases, Cases per Thousand Inhabitants, by Age Group, Legal Amazon Average, 2019



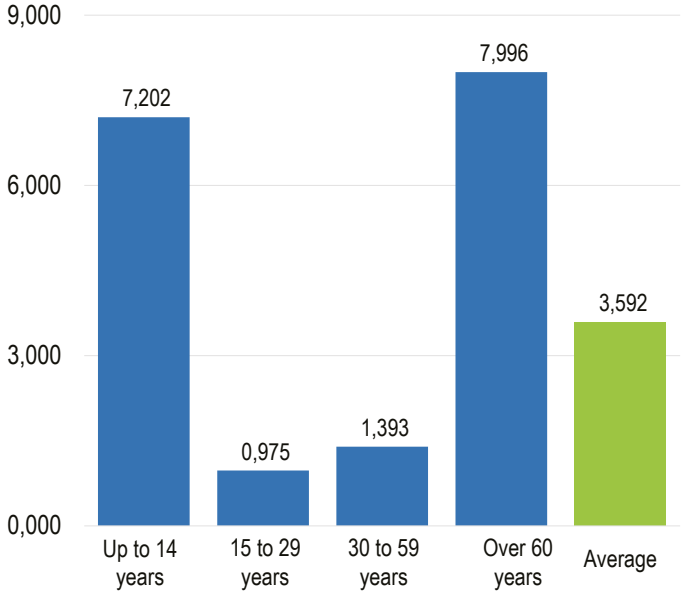
Source: Datasus and IBGE. Prepared by: Ex Ante Consultoria Econômica.

Chart 4.7
Hospitalizations due to Respiratory Diseases, Cases per Thousand Inhabitants, 2019



Source: Datasus and IBGE. Prepared by: Ex Ante Consultoria Econômica.

Chart 4.8
Hospitalizations due to Respiratory Diseases, Cases per Thousand Inhabitants, by Age Group, Legal Amazon Average, 2019



Source: Datasus and IBGE. Prepared by: Ex Ante Consultoria Econômica.

In broad statistical terms, the microdata from the 2019 National Health Survey indicates that **the probability of being absent from daily activities due to respiratory diseases was also negatively correlated with access to sewage collection and treated water services**.

The greater the access to these services, the lower the probability of absence due to respiratory diseases – see details in Methodological Annex 3. In this analysis, unlike that which relates sanitation availability to absences due to waterborne diseases, the availability of water is relatively more important, which is consistent with the idea that regular water supply is a precondition for handwashing, a practice that reduces the incidence of respiratory diseases.

Based on data from the Unified Health System, there were 658.2 thousand hospitalizations due to respiratory diseases3 throughout 2019 in Brazil. In hospitals accredited by SUS, 61 thousand deaths from respiratory diseases were recorded. In the Amazon, there were 104.1 thousand hospitalizations due to respiratory diseases in 2019. "The incidence of hospitalizations in this region, which was 3.592 cases per 1,000 inhabitants in 2019, exceeded the national average (Chart 4.7).

In terms of age groups (Chart 4.8), the highest incidence of these hospitalizations in the state occurred among children and the elderly: 7.202 cases per thousand inhabitants among children (under 14 years old), and 7.996 cases per thousand inhabitants among the elderly (over 60 years old).

[3] Respiratory diseases include only flu and pneumonia.

4.3. ACCESS TO SANITATION AND HEALTH

Table 4.1 presents the number of hospitalizations and the incidence rates of waterborne and respiratory diseases in 2024 for Brazil and for the Legal Amazon, detailing the two subregions and state-level statistics.

First of all, the area comprising the 772 municipalities of the Legal Amazon recorded a lower hospitalization incidence rate than the national average in that year, both for waterborne diseases and for respiratory diseases. Among the two subregions, the Eastern one showed the highest overall hospitalization rate. This was mainly due to waterborne diseases. In terms of these diseases, the states with the worst indicators were Maranhão, Rondônia, Amapá, and Pará.

Finally, the data in **Charts 4.9** and **4.10** show the relationship between the progress of sanitation in the group of municipalities of the Legal Amazon and the decline in the incidence of waterborne and respiratory diseases between 2005 and 2022.

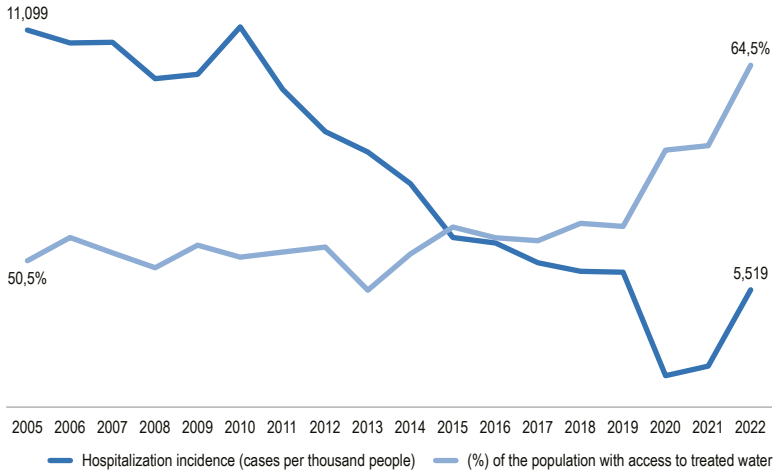
From 2005 to 2022, the incidence of waterborne and respiratory diseases declined in the group of 772 municipalities of the Legal Amazon. Over these 17 years, the rate fell from 11.099 cases per 1,000 inhabitants to 5.519 cases per 1,000 inhabitants. This represents a 50.3% reduction

Table 4.1
Hospitalizations due to Waterborne and Respiratory Diseases, Total Cases and Cases per Thousand Inhabitants, 2024

		Hospitalizations			Incidence (per thousand people)		
	Population (N)	Waterborne (A)	Respiratory Diseases (B)	Total (C=A+B)	Waterborne (A/N)	Respiratory Diseases (B/N)	Total (C/N)
Brazil	212.583.750	670.506	1.391.040	2.061.546	3,154	6,543	9,698
Legal Amazon	**28.332.744**	**68.294**	**103.604**	**171.898**	**2,410**	**3,657**	**6,067**
Regions							
Western	7.624.860	13.005	28.409	41.414	1,706	3,726	5,431
Eastern	20.707.884	55.289	75.195	130.484	2,670	3,631	6,301
States							
Rondônia	1.746.227	4.018	7.875	11.893	2,301	4,510	6,811
Acre	880.631	1.317	2.498	3.815	1,496	2,837	4,332
Amazonas	4.281.209	6.796	15.174	21.970	1,587	3,544	5,132
Roraima	716.793	874	2.862	3.736	1,219	3,993	5,212
Pará	8.664.306	19.170	31.178	50.348	2,213	3,598	5,811
Amapá	802.837	1.929	3.628	5.557	2,403	4,519	6,922
Tocantins	1.577.342	1.761	5.386	7.147	1,116	3,415	4,531
Maranhão	5.832.772	26.756	21.962	48.718	4,587	3,765	8,352
Mato Grosso	3.830.627	5.673	13.041	18.714	1,481	3,404	4,885

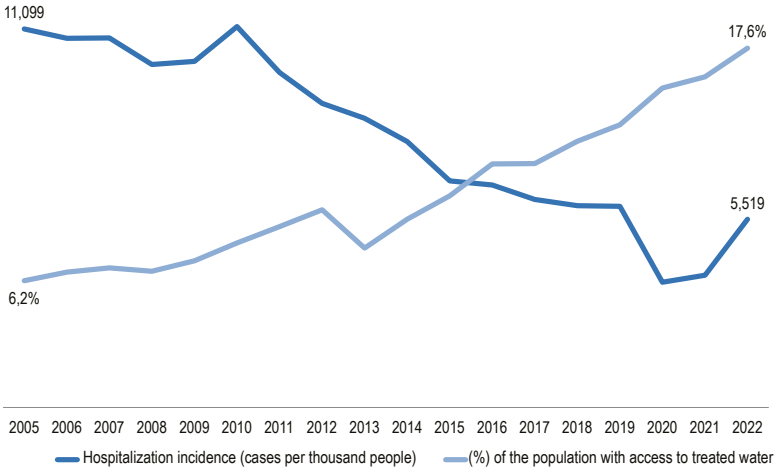
Source: Datasus and IBGE. Prepared by: Ex Ante Consultoria Econômica.

Chart 4.9
Hospitalization Rate due to Waterborne or Respiratory Diseases and Access to Treated Water Distribution Services, Legal Amazon, 2005 and 2022



Sources: DATASUS, SNIS, and IBGE. Prepared by: Ex Ante Consultoria Econômica.

Chart 4.10
Hospitalization Rate due to Waterborne or Respiratory Diseases and Access to Sewage Collection Services, Legal Amazon, 2005 and 2022



Sources: DATASUS, SNIS, and IBGE. Prepared by: Ex Ante Consultoria Econômica.

between 2005 and 2022. During this period, there was a simultaneous increase in the coverage rate of sanitation services. The share of the population with access to water rose from 50.5% in 2005 to 64.5% of the total population, and the percentage of people living in households with sewage collection increased from 6.2% to 17.6% over these 17 years.

5

PRODUCTIVITY AND ENVIRONMENTAL ENHANCEMENT

In addition to the immediate impacts on the health and quality of life of people living in degraded areas, the lack of treated water and sewage collection and treatment has a direct impact on the labor market and on economic activities that depend on good environmental conditions for their proper functioning. From the labor market perspective, the lack of sanitation affects labor productivity and student performance, with significant long-term effects on household income. There are two immediate channels linking the lack of sanitation to productivity loss:

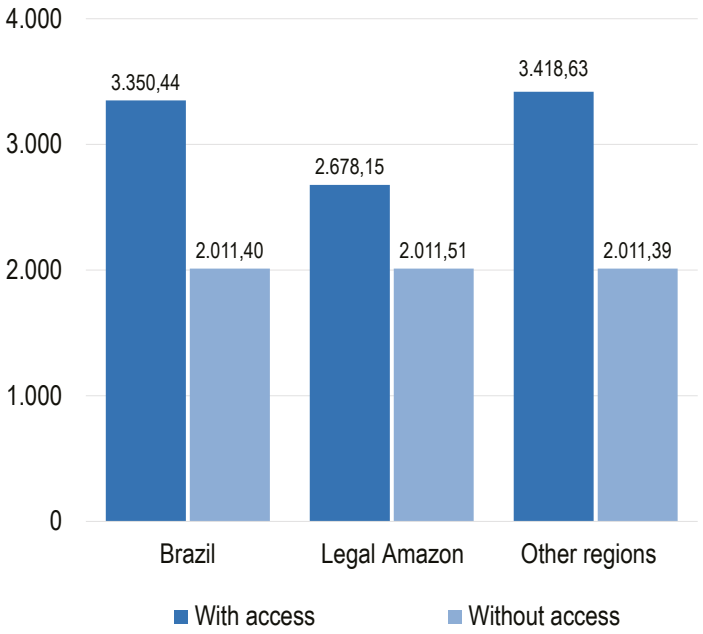
i. workers more susceptible to diseases caused by lack of sanitation experience poorer health and, consequently, lower productivity, which ultimately affects their career prospects and earning potential in the labor market; and

ii. recurrent infections keep children and young people away from school activities, harming their educational performance and, consequently, their future potential in the labor market.

From the environmental perspective, sanitation enhances the value of urban land, impacting the activities developed on it. Sanitation increases the value of existing buildings and allows for higher value-added construction, which results in an increase in the real estate capital of cities. In addition to raising the value of real estate assets and developments, sanitation enables the growth and enhancement of economic activities that depend on adequate environmental conditions, such as tourism.

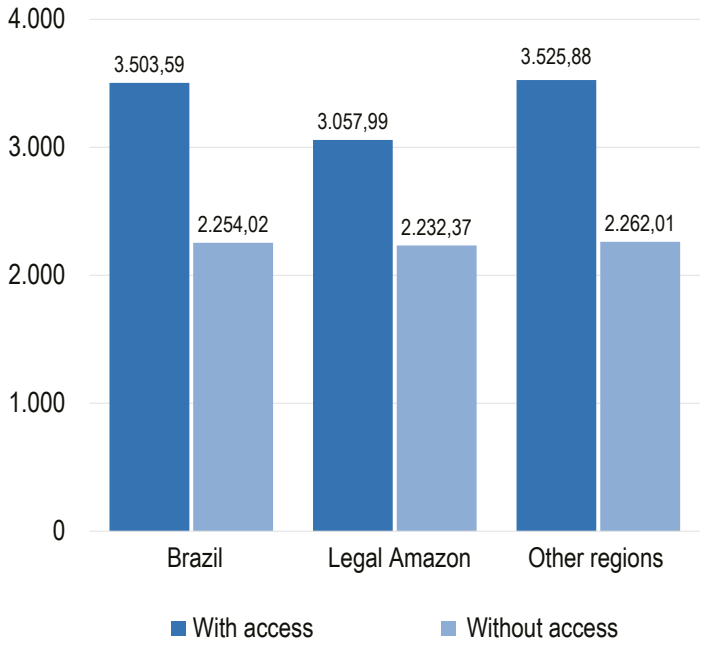
This chapter analyzes the externalities of sanitation on labor productivity, education, and environmental enhancement. The analyses focus on national data and data from the Legal Amazon region, making it possible to assess the differences between indicators that may be associated with sanitation This comparison allows, on the one hand, an evaluation of the

Chart 5.1
Average Labor Income by Group of Access to Water Supply Services, in BRL per Month, 2023



Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

Chart 5.2
Average Labor Income by Group of Access to Sewage Collection Services, in BRL per Month, 2023



Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

gains already achieved through the expansion of sanitation in the country, and on the other hand, an estimate of the legacy of universal basic sanitation achieved in the region. These analyses are the subject of the next chapter, which presents the balance between costs and benefits of universal sanitation in the region.

5.1. EFFECTS ON PRODUCTIVITY

Reductions in the incidence and severity of waterborne and respiratory diseases have economic effects that go beyond lowering healthcare expenditures and the losses from days not worked, which increase the costs of economic activities in the country. Improvements in health systematically increase workers' productivity.

Chart 5.1 presents the values of average monthly labor remuneration in each region, highlighting the average earnings of people living in households with access to treated water, on the one hand, and those living in households without access to basic sanitation, on the other. The data are striking: in Brazil, people living in households without access to treated water earned an estimated 40.0% less than those living in homes with treated water. In the Legal Amazon, the difference was smaller but still significant: 24.9% lower income.

The same occurs when comparing the average income of people living in households with sewage collection to the average income of those living in households without access to basic sanitation. In all regions, the average income is higher for people living in households with sewage collection. In the Legal Amazon, this difference was 27.0% in 2023. In Brazil, the difference was relatively greater, indicating that the average income of people living in households with sewage

collection was 35.7% higher than the average income of those living in households without access to basic sanitation.

The analysis conducted by Instituto Trata Brasil on this topic – Instituto Trata Brasil (2022) – supports this relationship. The study identified a very strong link between access to sanitation and the wages of Brazilian workers. The analysis, based on data from the 2019 Continuous National Household Sample Survey (PNADC), isolated the effect of access to sanitation on workers' income through a comprehensive statistical model addressing the determinants of productivity and labor income. By considering all factors together, it is possible to separate the specific effect of each one, isolating the particular contribution of sanitation to labor productivity. Methodological Annex 4 details this statistical analysis, indicating the broad set of control variables (economic and social) employed to identify the determinants of income and the partial effects of these variables on labor income.

Applying the same method to data from the 2023 Continuous National Household Sample Survey leads to similar conclusions. The most recent information indicates that workers living in areas with access to sewage collection services had, on average, wages 5.75% higher than those with the same employability conditions (education, experience, etc.) but living in places without sewage collection. Workers living in areas with access to the water distribution network had, on average, wages 5.66% higher than those with the same working conditions but without access to treated water. The lack of a bathroom in the household reduced labor income by 24.86%. Methodological Annex 4 details the analysis, indicating the broad set of control variables employed to identify the determinants of income.

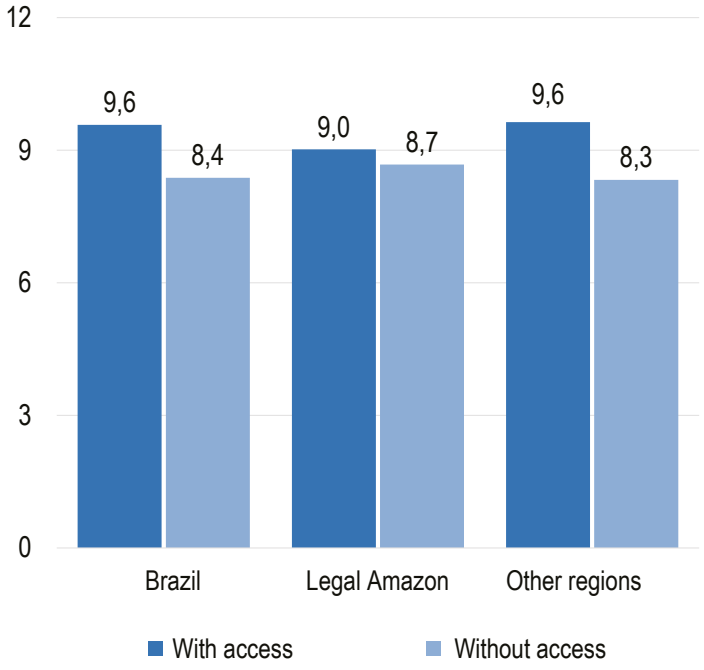
This difference, as previously mentioned, already reflects the partial effect of sanitation on productivity. Thus, the income differential has a direct interpretation: if sewage collection service is provided to a worker living in an area without access to this service, it is expected that the general improvement in their quality of life – reflected in lower morbidity from diarrhea or respiratory diseases, reduced frequency of absences, and fewer days missed at work, among other factors – will allow for higher productivity, with a corresponding increase in income. In this sense, it can be safely stated that the universal access to sanitation in the Legal Amazon will enable higher income for its workers in the future.

5.2. SANITATION AND EDUCATION

In addition to the effects on the productivity of the current workforce responsible for generating income in the country today, the expansion of sanitation services enables productivity gains for future generations of workers. This is because sanitation has a significant effect on school performance, as indicated by the study conducted by the Center for Social Policies (CPS-FGV, 2008).

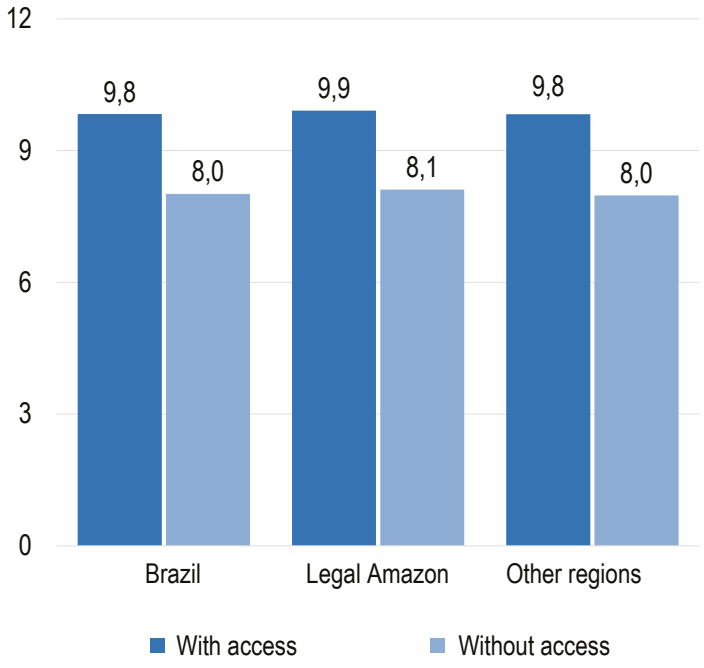
The present study presents a similar statistical model, which is analyzed in detail in Methodological Annex 5. Based on data from the 2023 Continuous National Household Sample Survey (IBGE, 2025), the effect of sanitation on school delay among young people was isolated from the effects of other socioeconomic variables on this performance indicator. The results confirm that school delay is greater among populations without access to sanitation. It was found that children and young people living in areas without access to sewage collection services had, on average, a school delay 2.21% greater than those living in places with sewage collection. Greater school delay indicates lower educational attainment. Those living in areas without access to the water distribution network had, on average, a school

Chart 5.3
Average Education Level, in Years of Study, by Group of Access to Water Supply Services, 2023



Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

Chart 5.4
Average Education Level, in Years of Study, by Group of Access to Sewage Collection Services, 2023



Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

delay 0.43% greater than that of children and young people living in areas with access to the public water supply network. The absence of a bathroom in the household increased school delay among young people by 20.22%.

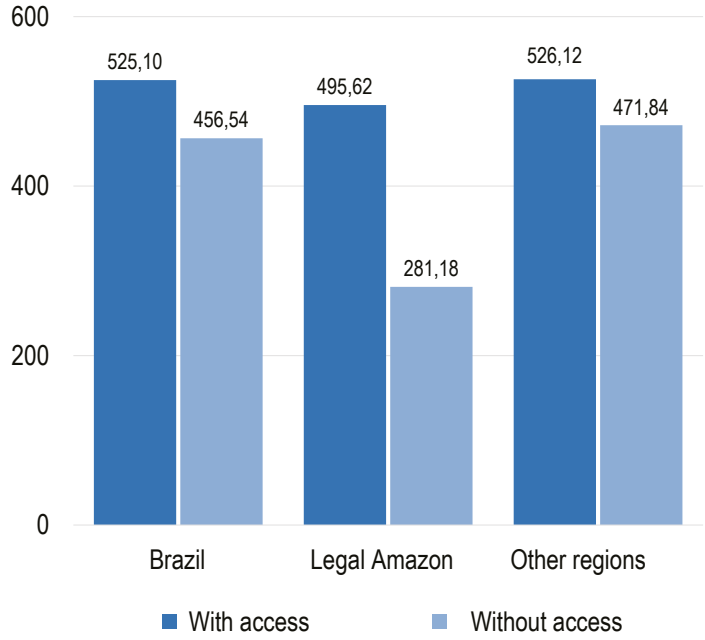
Charts 5.3 and **5.4** present the average schooling levels of the Brazilian population, the Legal Amazon, and the other regions of the country. For each area, estimates are provided for the educational attainment of people living in households with access to treated water (**Chart 5.3**) and with access to sewage collection services (**Chart 5.4**). Once again, the differences are striking: in Brazil, those living in households without access to water or sewage collection services had 12.5% and 18.5% less schooling, respectively, than people living in households with access to these sanitation services. In the Amazon, those living in households without access to water and sewage collection services had 3.8% and 18.1% less schooling, respectively, than people living in households with access to these sanitation services.

But there is another more immediate effect of the lack of sanitation on Brazilian students: sanitation affects the chances of progressing to higher education and the qualifications of young people who have just entered the labor market. This happens because sanitation influences students' average academic performance in terms of grades. Data from the 2023 High School National Exam (ENEM) show that young people living in households without an exclusive-use bathroom performed worse than those living in households with a bathroom. This relationship was valid both for Brazil and for the Legal Amazon.

As shown in **Table 5.1**, young people living in the 772 municipalities of the Legal Amazon and residing in households without a private bathroom had an average score 43.3% lower than those who had a bathroom in their home. The difference exceeded 50% in the tests of natural sciences, social sciences, and mathematics.

The statistical analysis confirmed the positive influence of access to sanitation on ENEM performance – see Methodological Annex 6. One consequence of this finding is that children and young people without access to basic sanitation will have lower professional qualifications than others when they enter the labor market.

Chart 5.5
Average ENEM Scores by Group of Access to Sewage Collection Services, 2023



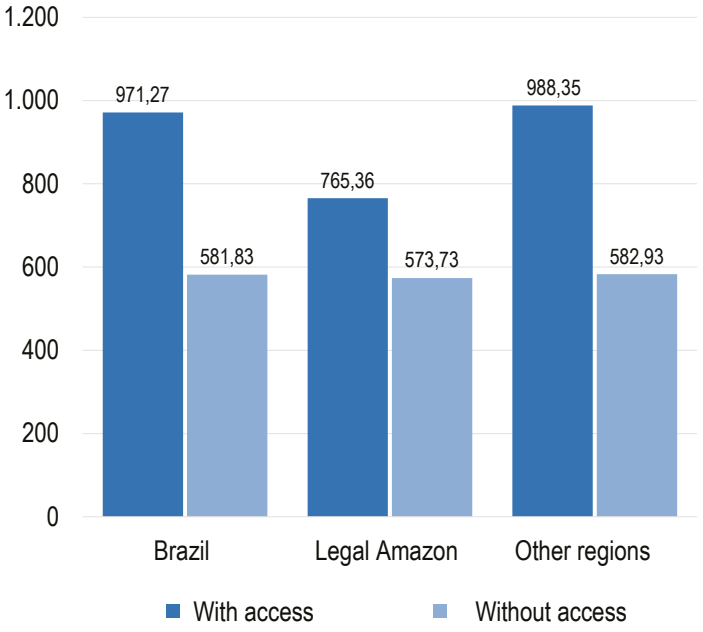
Source: Instituto Nacional de Ensino e Pesquisas Educacionais Anísio Teixeira (INEP).
Prepared by: Ex Ante Consultoria Econômica.

Table 5.1. Average ENEM Scores by Groups of Access to Sanitation, Legal Amazon, 2023

	With bathroom in the residence (A)	Without bathroom in the residence (B)	Difference (A-B)
Average	**495,62**	**281,18**	**214,45**
Natural Sciences	445,52	219,15	226,36
Human Sciences	481,67	230,30	251,37
Language and Codes	486,97	260,32	226,66
Mathematics	472,87	229,43	243,44
Written Essay	591,09	466,70	124,39

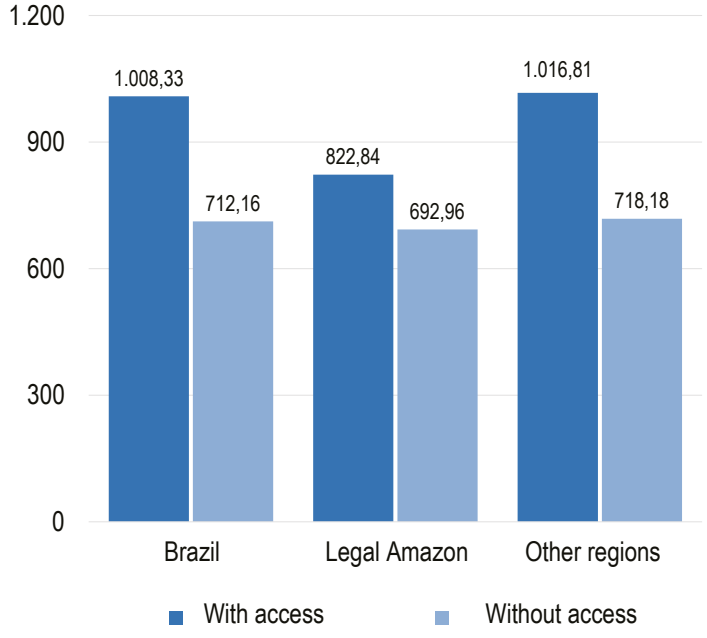
Source: Instituto Nacional de Ensino e Pesquisas Educacionais Anísio Teixeira (INEP). Prepared by: Ex Ante Consultoria Econômica.

Chart 5.6
Average Rent or Mortgage Payment of Residential Properties by Group of Access to Water Supply Services, in BRL per Month, 2023



Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

Chart 5.7
Average Rent or Mortgage Payment of Residential Properties by Group of Access to Sewage Collection Services, in BRL per Month, 2023



Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

5.3. REAL ESTATE APPRECIATION

As previously mentioned, sanitation enhances the value of urban land, increasing property values. Data illustrating this relationship are presented in **Chart 5.6**. In 2023, the average rent paid for Brazilian homes with access to treated water was 40.1% higher than that of homes without this service. When comparing homes with sewage collection to those without, this difference was 29.4% (**Chart 5.7**). In households of the Legal Amazon, these differences are also evident. The average monthly rents for homes with access to treated water and with sewage collection in the South Region were, respectively, BRL 765.36 and BRL 822.84 in 2023. For homes without access to these services, average monthly rents were lower: BRL 573.73 and BRL 692.96, respectively.

The statistical analysis based on IBGE data, conducted in the Instituto Trata Brasil (2022) study, confirmed this relationship by identifying a significant impact of sanitation on the value of real estate assets and on income generated by the sector. The methodology is presented in Methodological Annex 7. From the analyses, it was found that, considering two properties differing only in terms of access to sanitation, the one connected to the general sewage collection network had, on average, a 5.0% higher value than the one that was not connected. In the case of access to treated water, the value difference was 6.9% on average nationwide. The presence of a bathroom increased the value of the property by 18.5%. This indicates that proper sanitation, connecting a residence to the water distribution and sewage collection networks, could increase the property's value by 30.3%.

5.4. URBAN ENVIRONMENT AND TOURISM

In addition to increasing property values, sanitation enables the development of economic activities that depend on adequate environmental conditions for their operation, such as tourism. Tourism is, as is well known, an economic activity that does not develop properly in regions lacking sewage collection and treatment or treated water. Environmental contamination by sewage compromises, or even nullifies, a region's tourism potential.

The international statistics cited in the Instituto Trata Brasil (2022) study confirmed this idea. In 2019, according to data from the World Development Indicators (World Bank, 2021), countries with higher sanitation service coverage rates had better tourism performance, with proportionally higher numbers of foreign tourist arrivals. In contrast, nations with poor sanitation recorded fewer foreign visitors per inhabitant that year.

The loss of tourism potential is not only observed in international comparisons. Within the country itself and its regions, it is possible to identify the influence of sanitation on tourism development. The statistical analysis conducted in the Instituto Trata Brasil (2022) study to assess this issue identified a very strong relationship between access to sanitation and job creation in the tourism sector. For the country as a whole, areas with water distribution and sewage collection and treatment networks have, on average, higher volumes of tourism activity.

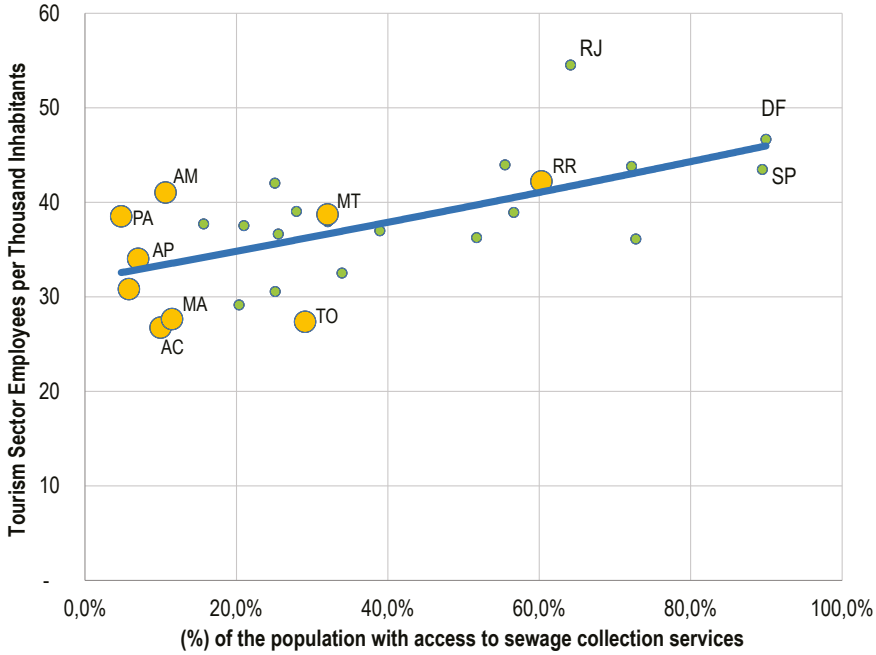
The estimates, based on data from the 2019 Continuous National Household Sample Survey (IBGE, 2020), indicated that an individual's probability of working in tourism activities, given their personal employability characteristics (age, education, gender, etc.), the region where they live, and their housing conditions, is affected by sanitation access conditions. For classification purposes, following the study on tourism in Brazil conducted by

the National Confederation of Services (CNS, 2021), the tourism sector includes the following activities: accommodation and food services; travel agencies; land passenger transportation; air transportation; and recreational, cultural, and sports activities.

In the present study, this model was updated with data from the 2023 Continuous National Household Sample Survey (IBGE, 2025). The estimates presented in Methodological Annex 8 indicated that, on the national average, individuals living in areas with access to basic sanitation had a higher likelihood of being employed in tourism-related activities. In other words, if a municipality lacks sanitation, the share of its population employed in tourism activities tends to be lower, reducing opportunities for both workers and entrepreneurs. Without adequate environmental conditions, tourism cannot fully develop its potential, as degraded areas fail to attract Brazilian or foreign tourists. Thus, there are lost business and employment opportunities.

Chart 5.8, based on data from the 2023 Continuous National Household Sample Survey (IBGE, 2025), illustrates the positive relationship between sewage collection service coverage and the share of people employed in the tourism sector across Brazilian states in 2023. States with greater provision of basic sanitation services, such as Rio de Janeiro, São Paulo, and Brasília, had higher proportions of people working in tourism. The states of the Legal Amazon, due to shortcomings in sanitation, had relatively smaller proportions of people involved in tourism. In this sense, the advancement of sanitation in the Legal Amazon is expected to have even more positive effects on the region's tourism potential.

Chart 5.8
Tourism Participation in Employment and Basic Sanitation, 2023



Source: RAIS and SNIS. Prepared by: Ex Ante Consultoria Econômica

6

ECONOMIC COST-BENEFIT BALANCE OF UNIVERSAL ACCESS TO SANITATION

This chapter presents estimates of the balances between the costs and economic benefits of investment in sanitation and of the universal access to services in the 772 municipalities that make up the Legal Amazon. The analysis considers the past, from 2005 to 2023, and the future, when positive gains from the universalization of basic sanitation services in these municipalities are still expected to emerge. The past gains provide a dimension of the increase in wealth in these municipalities that can be attributed to the effort to expand sanitation to a larger number of residents over the past 18 years, while the future gains should be seen as the expected benefits in the coming years as a result of the coordinated and systematic effort to expand the sector and the legacy for future generations of the universalization of sanitation.

The past estimates are based on historical data obtained from the National Sanitation Information System (SNIS), the IBGE annual household sample surveys, and the databases of the Unified Health System (SUS) and the Ministry of Economy. The steps for estimating the balance values between benefits and costs presented in the tables of this chapter are detailed in Methodological Annex 9.

6.1. THE LAST 18 YEARS

Table 6.1 presents the estimates of the benefits and costs of the sanitation expansion that took place between 2005 and 2023 in the group of municipalities of the Legal Amazon. Over this period, the benefits reached BRL 176.5 billion, of which BRL 122.1 billion were direct benefits (income generated by investment and sanitation activities, and consumption and production taxes collected) and BRL 54.4 billion were due to the reduction of losses associated with externalities. The social costs incurred during the period amounted to BRL 85.6 billion. Thus, the benefits exceeded the costs by BRL 90.8 billion, indicating a positive social balance for the municipalities of the Legal Amazon.

The following section presents in greater detail the values of each component of the costs and benefits of sanitation progress.

REDUCTION IN HEALTHCARE COSTS

Between 2005 and 2023, there was a 3.1% annual reduction in the number of hospitalizations. This led to a reduction in costs from paid hours not worked due to absences caused by diarrhea or vomiting and by respiratory diseases. In addition, there was a decrease in expenses related to hospitalizations for gastrointestinal and respiratory infections within the SUS healthcare network. The present value of the total savings from the improvement in health conditions of the population of these municipalities between 2005 and 2023 was BRL 6.4 billion, which resulted in an annual gain of BRL 353 million.

INCREASE IN PRODUCTIVITY

To estimate the effect of sanitation progress on labor productivity, we used data from the IBGE household sample surveys conducted between 2005 and 2023. Based on the statistical model of labor productivity and wage determinants, it is estimated that productivity increased due to the dynamics of sanitation in the Legal Amazon. The present value of the increase in labor income from the sanitation expansion between 2005 and 2023 was BRL 39.3 billion, resulting in an annual gain of BRL 2.183 billion (**Table 6.1**).

REAL ESTATE APPRECIATION

In terms of real estate income, there were gains for property owners who rent or live in their own homes, despite the slow progress of sanitation between 2005 and 2023. Over the entire period, residents experienced an income gain of approximately BRL 5.1 billion. This amount was calculated based on the estimated housing stock in 2023 and the average rents – paid or implicit, that is, the opportunity cost for owners of self-occupied properties – in 2023, compared to what would have prevailed in 2005 had sanitation conditions remained unchanged between 2005 and 2023.

Table 6.1
Costs and Benefits of Sanitation Expansion, Legal Amazon, 2005 to 2023

Costs and Benefits	in BRL million*	
	per year	2005-2023
Reduction in healthcare costs	352,956	6.353,210
Increase in labor productivity	2.182,809	39.290,570
Income from real estate appreciation	281,518	5.067,322
Tourism income	204,377	3.678,782
Subtotal externalities (A)	3.021,660	54.389,883
Income generated by investment	2.503,859	45.069,462
Income generated by increased operations	3.931,879	70.773,826
Taxes related to production**	345,896	6.226,121
Subtotal income (B)	6.781,634	122.069,409
Total benefits (C=A+B)	**9.803,294**	**176.459,292**
Investment cost	-1.955,809	-35.204,565
Increase in household expenses	-2.801,294	-50.423,299
Total costs (D)	**-4.757,104**	**-85.627,864**
Balance (E=C+D)	**5.046,190**	**90.831,428**

Estimates: Ex Ante Consultoria Econômica. (*) present values at 2024 prices.
(**) from sanitation investments and operations and real estate activities.

TOURISM INCOME

Between 2005 and 2023, the present value of tourism gains reached BRL 3.7 billion, indicating an average annual flow of BRL 204 million during the period. This gain resulted from the environmental improvements achieved through the cleanup of rivers and streams in the capital and the expansion of universal access to treated water in some areas. As will be seen later, progress in sanitation toward universalization is expected to bring major advantages for the municipalities of the Legal Amazon.

INCOME GENERATED BY INVESTMENT

As discussed in Chapter 3, investments in sanitation generate jobs and income along the construction sector's production chain. This income is a direct benefit of the investments which, when subtracted from the cost of the expenditures in this area, provides a direct estimate of the net benefits of expanding sanitation infrastructure. Between 2005 and 2023, the present value of sanitation investments reached BRL 35.2 billion in the municipalities of the Legal Amazon. The direct, indirect, and induced income generated by these investments totaled BRL 45.1 billion. Thus, the income surplus generated by the investments amounted to approximately BRL 9.9 billion over the period.

INCOME FROM OPERATIONS

Likewise, sanitation operations generate jobs and income along the water and sewage sector's production chain. The increase in income results from the sector's increased revenues, which must be subtracted from the operational costs borne by households to obtain a direct estimate of the net benefits from sanitation operations. In this case, however, it is not the total income and expenses incurred by society that are summed, but rather the incremental gains over time. Between 2005 and 2023, the present value of the income increase in sanitation operations reached BRL 70.8 billion in the municipalities of the Legal Amazon. The present value of the increase in household expenses related to these operations totaled BRL 50.4 billion. Thus, the income surplus generated by the increase in operational revenues amounted to approximately BRL 20.4 billion in the period from 2005 to 2023.

6.2. THE BALANCE OF UNIVERSAL ACCESS TO SANITATION

The analysis developed in the previous section allows us to infer that the municipalities of the Legal Amazon have already achieved gains in the recent past. However, there is an important difference when looking toward the future. In addition to the balance between costs and benefits during the forthcoming process of universal access to sanitation – a period in which more will be invested to reduce the historical sanitation deficits in the region, especially those related to sewage collection and treatment – it is also necessary to consider the legacy that universalization will leave for the future. After universal access is achieved, the gains from externalities – health, productivity, and environmental enhancement – will endure permanently, thus exceeding the very period of universalization, which is expected to be reached in 2040.

This section analyzes the expected gains from the expansion of sanitation in the Legal Amazon and the legacy of universal access for the future of these municipalities. The analysis focuses on two periods: (i) from 2024 to 2040, which is the time frame within which universal access to sanitation is expected, and (ii) the subsequent period, beyond 2040, when the enduring legacy of the achievements of the next decade will take place.

With regard to the 2040 milestone, it is worth noting that a significant share of the municipalities are expected to reach universal access by 2033, as set forth in the goals of the new sanitation regulatory framework, as argued in the introduction of this study. In addition, including the years 2034 to 2040 in the analysis of the benefits of universal access to sanitation by 2033 makes it possible to capture later effects of investments, particularly those carried out between 2030 and 2033, which will not yet be fully felt by 2033.

Table 6.2 presents the estimates of costs and benefits of sanitation expansion in the group of

Table 6.2
Costs and Benefits of Sanitation Universalization, Legal Amazon, 2024 to 2040

Costs and Benefits	in BRL million*	
	per year	2024-2040
Reduction in healthcare costs	158,936	2.701,920
Increase in labor productivity	11.347,581	192.908,873
Income from real estate appreciation	1.476,721	25.104,264
Tourism income	1.302,748	22.146,714
Subtotal externalities (A)	14.285,987	242.861,772
Income generated by investment	10.269,766	174.586,026
Income generated by increased operations	4.990,927	84.845,761
Taxes related to production**	838,957	14.262,275
Subtotal income (B)	16.099,651	273.694,062
Total benefits (C=A+B)	**30.385,637**	**516.555,834**
Investment cost	-7.927,035	-134.759,591
Increase in household expenses	-3.042,531	-51.723,030
Total costs (D)	**-10.969,566**	**-186.482,621**
Balance (E=C+D)	**19.416,071**	**330.073,213**

Estimates: Ex Ante Consultoria Econômica. (*) present values at 2024 prices.
(**) from sanitation investments and operations, and real estate activities.

municipalities of the Legal Amazon for the period from 2024 to 2040. Over this period, the benefits are expected to reach BRL 516.6 billion, of which BRL 273.7 billion are direct benefits (income generated by investment and sanitation activities, and consumption and production taxes collected) and about BRL 242.9 billion are due to the reduction of losses associated with externalities. The social costs during the period are expected to total approximately BRL 186.5 billion. Thus, the benefits are expected to exceed the costs by nearly BRL 330.1 billion, indicating a highly positive social balance for the region.

The following section presents in greater detail the values of each component of the costs and benefits of sanitation progress.

REDUCTION IN HEALTHCARE COSTS

Between 2024 and 2040, it is estimated that there will be a reduction in costs from paid hours not worked due to absences caused by diarrhea or vomiting and by respiratory diseases, as well as a reduction in expenses related to hospitalizations for gastrointestinal and respiratory infections in the SUS hospital network in the municipalities of the Legal Amazon. The present value of the total savings from the improvement in health conditions of the population of these municipalities between 2024 and 2040 is expected to be BRL 2.702 billion, resulting in an annual gain of BRL 158.9 million.

INCREASE IN PRODUCTIVITY

Based on the statistical model of the determinants of productivity and labor income, we estimate that there will be a strong increase in productivity due to the future dynamics of sanitation in the municipalities of the Legal Amazon. The present value of the increase in labor income from the sanitation expansion between 2024 and 2040 will be BRL 192.9 billion, resulting in an annual gain of BRL 11.3 billion (**Table 6.2**).

REAL ESTATE APPRECIATION

In terms of real estate income, we estimate that the gain for property owners who rent or live in their own homes will be BRL 1.477 billion per year in the group of municipalities of the Legal Amazon, totaling a present value gain of BRL 25.1 billion between 2024 and 2040. This amount was calculated using as a reference the estimated housing stock of 2023 and the average rent values – paid or implicit, that is, the opportunity cost of homeowners living in their own properties – in 2023, and those expected to prevail with the universalization of sanitation.

TOURISM INCOME

Between 2024 and 2040, the present value of tourism gains shall reach BRL 22.1 billion, indicating an average annual flow of BRL 1.303 billion during the period. This gain results from the environmental enhancement that can be achieved through the depollution of rivers and streams and the universal provision of treated water, preconditions for the full exercise of tourism activities.

INCOME GENERATED BY INVESTMENT

Between 2024 and 2040, the present value of sanitation investments is expected to reach BRL 134.8 billion in the municipalities of the Legal Amazon. The direct, indirect, and induced income generated by these investments shall total BRL 174.6 billion. Thus, the surplus income generated by the investments should amount to approximately BRL 39.8 billion in the period.

INCOME FROM OPERATIONS

Between 2024 and 2040, the present value of the income increase from sanitation operations is expected to reach BRL 84.8 billion in the municipalities of the Legal Amazon. The present value of the increase in household expenditures on these operations is expected to total BRL 51.7 billion. Thus, the surplus income generated by the expansion of sanitation operation revenues will be approximately BRL 33.1 billion in the period from 2024 to 2040.

THE LEGACY OF UNIVERSAL ACCESS

The value of the externalities' legacy is calculated as the present value of the perpetual income from the benefits after universalization, based on the same financial conditions previously described. The costs and benefits of investments after 2040 are calculated by considering an annual investment amount sufficient to offset a depreciation rate of 5% per year and a decreasing demographic growth. The discount rate applied is 5.8% per year.

Table 6.3 presents the estimates of the future legacy for the population of these municipalities from the universal access to sanitation in the Legal Amazon. The reduction in healthcare costs, considering both hospitalization expenses and the losses from paid hours not worked, is expected to generate a total gain of BRL 2.970 billion in the economy of these municipalities. The increase in labor productivity is expected to amount to BRL 206.3 billion. The projected increase in real estate income has a total present value of BRL 37.5 billion. The projected increase in tourism income has a total present value of BRL 32.3 billion. Thus, the present value of the externalities associated with universal access to basic sanitation in these cities is estimated at BRL 279.3 billion.

In addition to the benefits of externalities, there are income gains from ongoing investments after universalization for system maintenance and from the continued growth of sanitation operations. It is estimated that total income gains will reach BRL 176.2 billion in the post-2040 period.

The total costs of maintaining universalization will be approximately BRL 113.5 billion after 2040. Thus, in line with what was previously analyzed, the balance of universal access to sanitation by 2040 must be added to a perpetuity balance of BRL 342.1 billion, totaling welfare gains of BRL 972.1 billion from 2024 onward.

Table 6.3
Costs and Benefits of Sanitation Universalization, Legal Amazon, post-2040

Costs and Benefits	in BRL million*	
	per year	Perpetuity
Reduction in healthcare costs	172,992	2.969,973
Increase in labor productivity	12.035,857	206.634,352
Income from real estate appreciation	2.181,955	37.460,310
Tourism income	1.878,829	32.256,171
Subtotal externalities (A)	16.269,635	279.320,807
Income generated by investment	4.100,082	70.391,151
Income generated by increased operations	5.640,329	96.834,453
Taxes related to production**	524,853	9.010,796
Subtotal income (B)	10.265,264	176.236,400
Total benefits (C=A+B)	**26.534,899**	**455.557,207**
Investment cost	-3.170,613	-54.433,802
Increase in household expenses	-3.438,414	-59.031,485
Total costs (D)	**-6.609,027**	**-113.465,287**
Balance (E=C+D)	**19.925,872**	**342.091,920**

Estimates: Ex Ante Consultoria Econômica. (*) present values at 2024 prices.
(**) from sanitation investments and operations, and real estate activities.

This relationship indicates **that for every BRL 1.00 invested in sanitation from 2024 onward, the 772 municipalities of the Legal Amazon are expected to achieve social gains of BRL 5.10**, a return greater than that expected for Brazil as a whole.

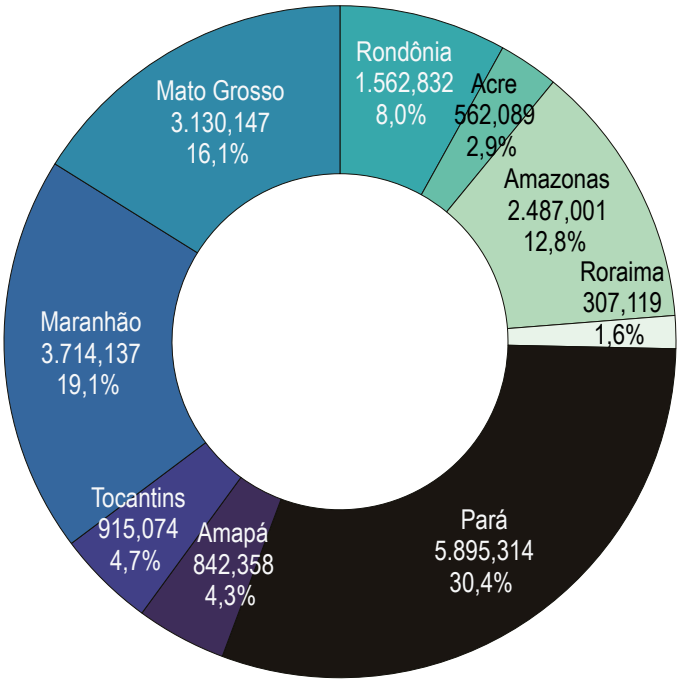
In addition, the preservation and depollution of the region's water sources, rivers, streams, and lakes, with inestimable environmental gains, will be a major legacy of universal access to sanitation in the municipalities of the Legal Amazon. The depollution of urban environmental resources is an achievement that was reached years ago in major metropolitan areas of developed countries, with the environmental recovery of rivers and basins that were highly polluted in the past. In the case of the Amazon, the preservation of natural heritage is combined with the recovery of degraded areas in these 772 municipalities.

6.3. THE BALANCE OF UNIVERSAL ACCESS IN THE REGIONS OF THE LEGAL AMAZON

Chart 6.1 shows the distribution of net gains from universal access to sanitation among the nine states that make up the Legal Amazon. The net gains include those up to 2040. Among the nine federative units, Pará, Maranhão, and Mato Grosso stand out, whose gains are expected to represent 30.4%, 19.1%, and 16.1% of the total gains in the 772 municipalities of the Legal Amazon, respectively.

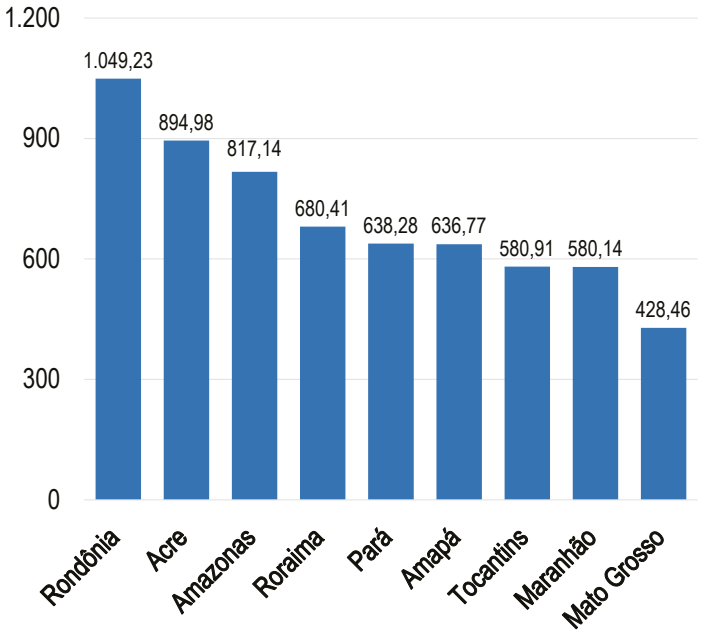
Despite the concentration of gains in these three federative units, it is worth noting that per capita gains will be greater in the states of Rondônia, Acre, and Amazonas. **Chart 6.2** presents these estimates.

Chart 6.1
Distribution of Universalization Gains among States of the Legal Amazon, in BRL Billion per Year and (%) of the Total, 2024 to 2040



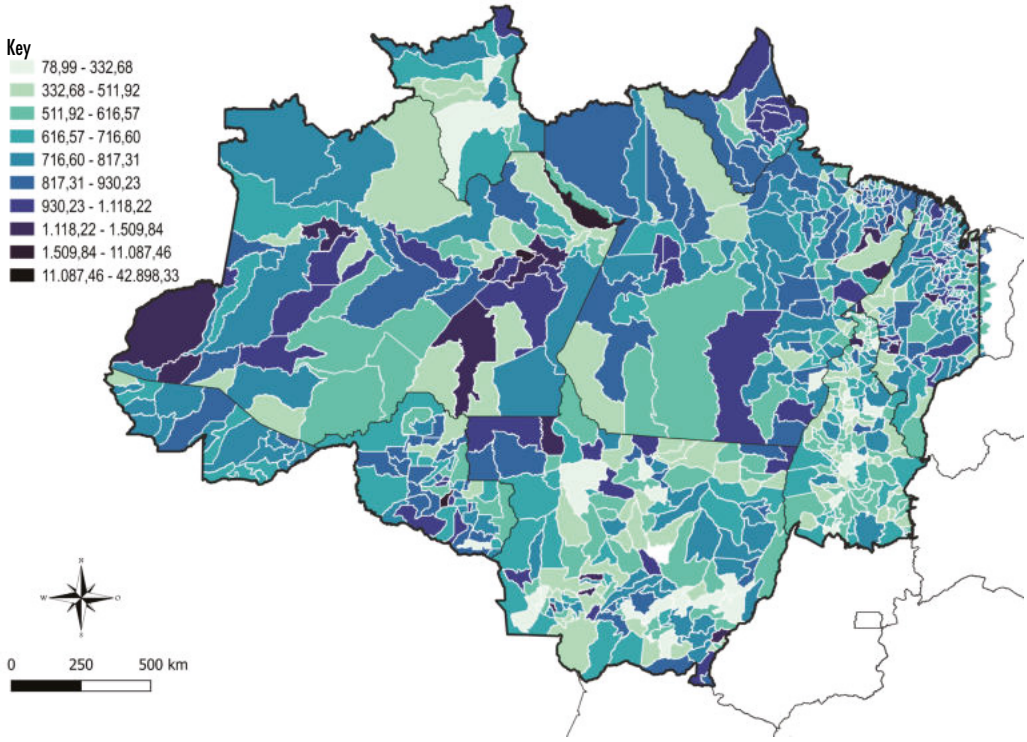
Estimates: Ex Ante Consultoria Econômica. (*) Includes gains up to 2040 and the legacy after universalization.

Chart 6.2
Per Capita Gains from Universalization in the States of the Legal Amazon, in BRL per Inhabitant per Year, 2024 to 2040



Estimates: Ex Ante Consultoria Econômica. (*) Includes gains up to 2040 and the legacy after universalization.

Map 6.1 Per Capita Gains from Universalization in the Municipalities of the Legal Amazon, in BRL per Inhabitant per Year, 2024 to 2040

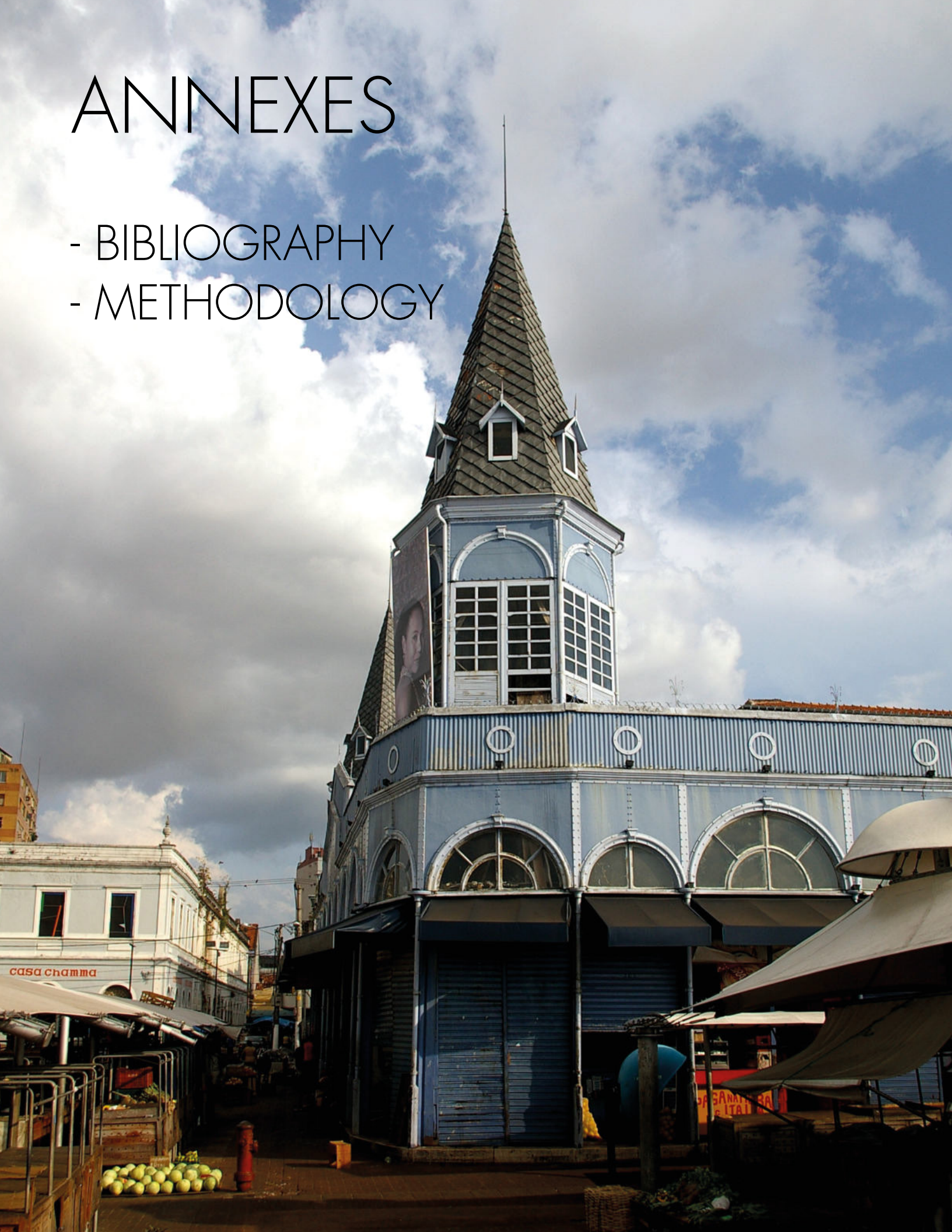


Estimates: Ex Ante Consultoria Econômica. (*) Includes gains up to 2040 and the legacy after universalization.

Finally, **Map 6.1** shows the distribution of per capita gains among the 772 municipalities of the Legal Amazon. The municipalities in darker colors represent those where the largest per capita gains are expected, while those in lighter colors represent the smallest gains. The main factor explaining this distribution is the current state of deprivation of sanitation services in each municipality: in those where coverage of water supply and sewage collection and treatment services is low, the gains tend to be relatively greater. Another factor that decisively affects these estimates is the pattern of economic activities in each municipality. In municipalities where the workforce is larger and more active, productivity gains are relatively higher. Environmental enhancement also positively contributes to generating benefits, especially in the region's larger municipalities.

ANNEXES

- BIBLIOGRAPHY
- METHODOLOGY



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METHODOLOGICAL ANNEX

1. THE EFFECT OF SANITATION INFRASTRUCTURE INVESTMENTS AND SEWAGE COLLECTION AND TREATMENT OPERATIONS ON EMPLOYMENT AND INCOME

The methodology used to estimate the impacts of sanitation infrastructure investments and sewage collection and treatment operations on employment and income generation is based on the Leontief Model of fixed-coefficient production. This annex details the theoretical concepts, databases, and methodological procedures applied in this study.

Theoretical Model

The Leontief Model is based on the input-output matrix, which represents the various intersectoral transactions within an economy over the course of a year. The economy consists of m productive sectors, or activities, which participate in the flow of goods and services used as inputs and outputs. The intersectoral flows have the typical structure described in Figure A.1.

The main variables that define the input-output relationships are:

X_{ij}: the amount of input, in monetary value, produced by sector i and purchased by sector j;
X_i: the total monetary value of production in sector i;
DF_i: the monetary value of final demand for sector i's input, which corresponds to the sum of household consumption of this input (Ci), private investment (Ii), government spending (Gi), and exports (Ei);
V_i the value added by sector j

In row *i*, the sales of sector *i* to each of the other sectors of the economy are shown, such that:

$$X_i = \sum_{j=1}^{m} X_{ij} + (C_i + I_i + G_i + E_i)$$

, or even:

$$X_i = \sum_{j=1}^{m} X_{ij} + DF_i$$

The total demand equals total supply, which is composed of final demand, made by consumers, investors, and government, and intermediate demand, also called intermediate consumption.

The input-output model assumes that the quantity of input from sector i consumed by sector *j* (X_{ij}) is proportional to the total production of sector *j* (X_j). In the model, $X_{ij} = a_{ij} . X_j$, where a_{ij} is a constant that expresses the amount of input i required to produce one unit of output j. In other words, the consumption by sector j of inputs from sector i is a linear function of its own level of production.

Thus, to double its production, for example, sector j requires twice the amount of inputs from sector i. The matrix A = (a_{ij}) is known as the technology matrix, and its elements 'a_{ij}' are called direct input technical coefficients.

From these relationships, a linear system of m equations with m unknowns is obtained:

$$X_i = \sum_{j=1}^{m} X_{ij} + DF_i = \sum_{j=1}^{m} a_{ij} X_j + DF_i \,,\; i = 1, 2, \ldots, m,$$

that is, $a_{i1}X_1 + a_{i2}X_2 + \ldots + a_{in}X_n + DF_i = X_i$, i = 1, 2, 3, ...,*m*. In matrix form, this system can be written as:

AX + DF = X, or equivalently, (I – A).X =DF

where A is the technology matrix, a square matrix of dimension m×m; X is a column vector m×1 whose elements are the production values of the various sectors; DF is the column vector m×1 corresponding to final demand; I is the identity matrix, also of dimension m×m.

Note that, in general, the intermediate consumption of a sector does not exceed its total production, that is:

$$X_j > \sum_{i=1}^{m} X_{ij} \quad ,j = 1, 2, 3, \ldots, m.$$

This means that, $1 > \sum_{i=1}^{m} a_{ij}$ *j* = 1, 2, 3, ..., *m*.Thus, the system above can be solved for X: as described by equation (1). The matrix L = (I - A)-1 is called the Leontief inverse matrix. System (1) shows how much the economy produces of each good and service to meet the economy's total demand.

$$X = (I - A)\text{-}1 \,.\, DF = L.DF \qquad (1)$$

Figure A.1.
Input-Output Table

		Sector j Consumption	Final Demand	X
Product of Sector i		$\begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1j} & \cdots & X_{1m} \\ X_{21} & X_{22} & \cdots & X_{2j} & \cdots & X_{2m} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ X_{i1} & X_{i2} & \cdots & X_{ij} & \cdots & X_{im} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ X_{m1} & X_{m2} & \cdots & X_{mj} & \cdots & X_{mm} \end{bmatrix}$	$\begin{bmatrix} C_1 & I_1 & G_1 & E_1 \\ C_2 & I_2 & G_2 & E_2 \\ \vdots & \vdots & \vdots & \vdots \\ C_i & I_i & G_i & E_i \\ \vdots & \vdots & \vdots & \vdots \\ C_m & I_m & G_m & E_m \end{bmatrix}$	$\begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_i \\ \vdots \\ X_m \end{bmatrix}$
Expenditure		$\begin{bmatrix} CI_1 & CI_2 & \cdots & CI_j & \cdots & CI_m \\ V_1 & V_2 & \cdots & V_j & \cdots & V_m \\ M_1 & M_2 & \cdots & M_j & \cdots & M_m \end{bmatrix}$		
X		$\begin{bmatrix} X_1 & X_2 & \cdots & X_j & \cdots & X_m \end{bmatrix}$		

Prepared by: Ex Ante Consultoria Econômica.

In order to measure economic impacts on income and employment using the input-output matrix, employment and income multipliers are constructed. The direct employment coefficient CED_j, j = 1, 2, ..., m is obtained by dividing the number of workers in each sector j, N_j, by the corresponding production value, X_j. By composing a row vector (1×m) with these ratios, we have:

$$CED = (N_1/X_1 \;\; N_2/X_2 \;\; \ldots \; N_m/X_m) \qquad (2)$$

That is, to produce one unit of output in sector j, CEDj workers are required in sector j itself, following the Leontief assumption of linear relationships. In addition to the direct impact, there is an indirect employment effect throughout the economy, since the sector in question requires inputs from other sectors. To calculate this effect, the L matrix is multiplied by the demand column vector (m×1), that is, Z = L.DF. Thus, employment generated by the demand is given by P= CED.Z =(CED.L).DF = CEDI. DF. The row vector CEDI (1x), which equals CED.L, is known as the vector of direct and indirect employment coefficients.

$$CEDI = CED \; . \; L \qquad (3)$$

Similarly, it is also possible to calculate the direct income coefficients based on the "Value Added" row from Figure A.1, as well as the direct and indirect income coefficients. These values are expressed in equations (4) and (5).

$$CRD = (V1/X1 \; V2/X2 \; \ldots Vm/Xm) \qquad (4)$$

$$CRDI = CRD.L \qquad (5)$$

Induced employment and income generated by an activity in a given location are calculated by applying the direct and indirect multipliers to the demand generated by the consumption of workers employed in that activity. By assumption, the additional consumption of workers in activity i (CFi) is proportional to the income of these workers: $CF_i = l.W$, where W is the payroll of sector i and l is the propensity to consume, which is a constant greater than zero and less than 1. Thus, to calculate the induced employment and income generated by an activity, it is sufficient to multiply the vector CF_i by the direct and indirect employment and income coefficients (expressions 3 and 4).

Databases

To estimate the impacts of investments in sewage collection networks and wastewater treatment plants, data from the 2021 Annual Survey of the Construction Industry, conducted by IBGE, were used. This survey provides the direct income and employment coefficients for sanitation works, as well as the wages paid by construction companies to carry out these projects. The 2021 supply and use tables from Brazil's National Accounts, also provided by IBGE, offer the data needed to estimate the L matrix, indirect employment and income coefficients, and households' propensity to consume.

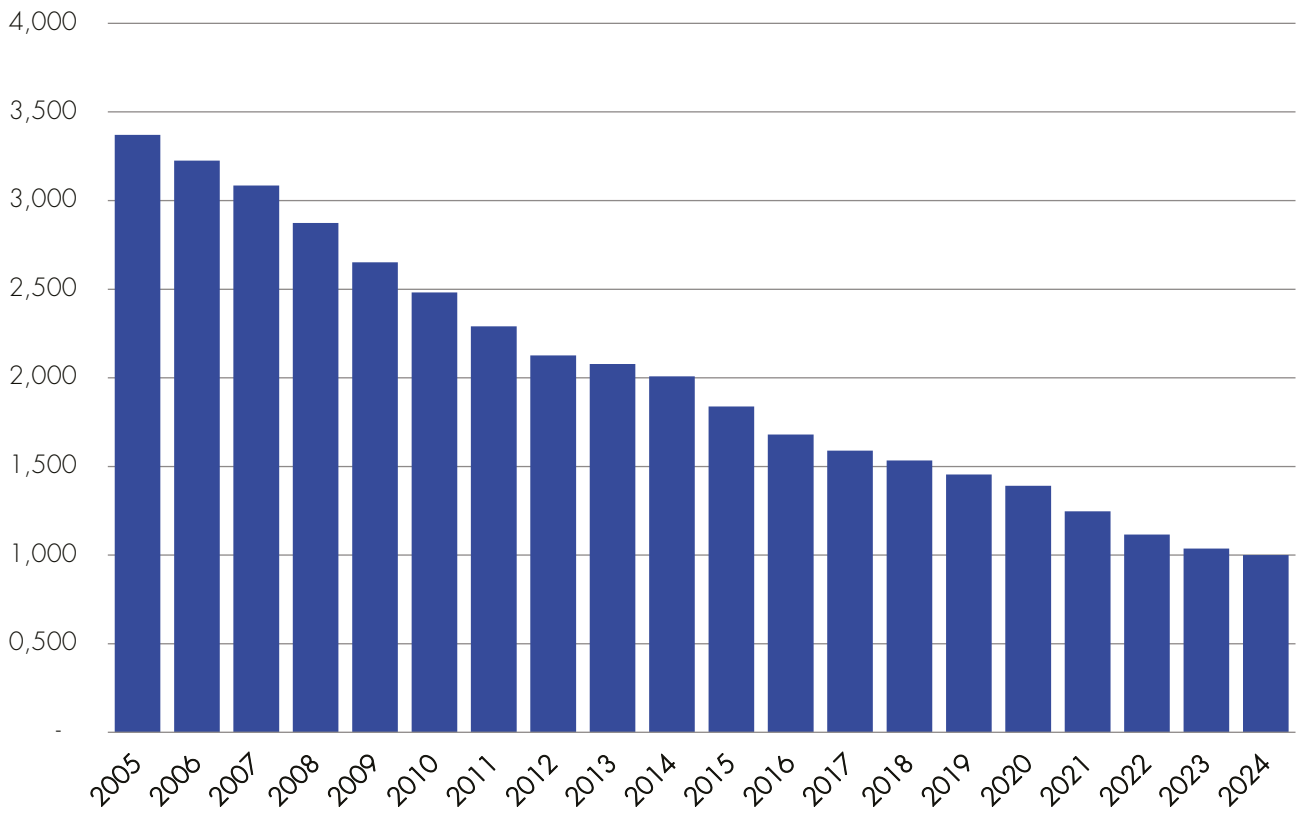
For sewage collection and treatment operations, the data on production value, employment, income, and wages required for calculating the direct and induced coefficients come from the 2021 Annual Survey of Services, also conducted by IBGE. Similarly to the previous case, the data used to estimate the L matrix, indirect employment and income coefficients, and households' propensity to consume were taken from the 2021 supply and use tables of Brazil's National Accounts.

Investment Deflator

To estimate the value of sanitation investments in constant prices, investment deflators were created to convert past current values into constant 2024 prices. For this purpose, data from two surveys were used: (i) the Annual Survey of the Construction Industry (PAIC), from 2005 to 2021, conducted by IBGE (IBGE, various years), which provides information on material and labor costs for sanitation network works; and (ii) data from the National System of Costs Survey and Indexes of Construction (SINAPI), available on the IBGE website, which provide estimates of labor and material cost trends for construction in Brazilian states and the Federal District.

The values of sanitation works recorded in PAIC were used to estimate the weight of labor and materials in total investment costs. SINAPI data were used to calculate the estimated annual variations of these components. The variation of the investment deflator is the weighted average of the variations in labor and materials for each region, according to their respective weights. Based on these variations, an index was created with a base value of 1 for 2024. The constant investment value is obtained by multiplying the current value by the corresponding deflator.

Chart A.1. Investment Deflator, 2024 = 1

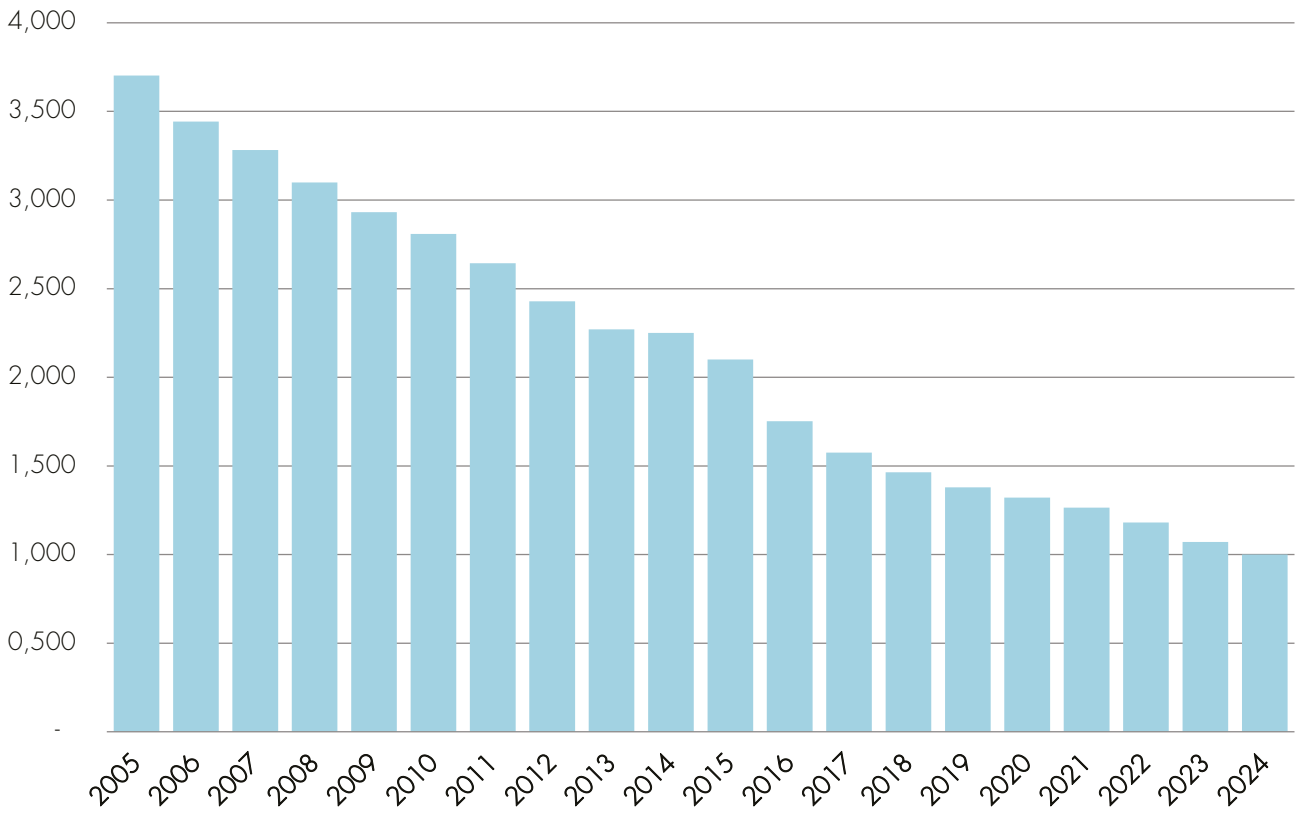


Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

Revenue Deflator

To estimate sanitation revenues at constant prices, an index was created based on the evolution of the weighted average tariff for water and sewage services in Brazil. The index has a base of 2024 = 1, and the tariffs were obtained from IBGE's IPCA.

Chart A.2. Investment Deflator, 2024 = 1



Source: IBGE. Prepared by: Ex Ante Consultoria Econômica.

2. SANITATION AND MORBIDITY OF INFECTIOUS GASTROINTESTINAL DISEASES

The analysis of the effects of sanitation on the incidence of diarrhea was based on the cross-referencing of information on work absences due to diarrhea and vomiting, access to sewage, access to treated water, availability of a private bathroom, and socioeconomic indicators. To calculate these effects, data from the 2019 National Health Survey conducted by IBGE were used. The socioeconomic indicators used in the econometric models are: (i) information about individuals: age, gender, and whether they study or work; and (ii) information about the household: type of dwelling (apartment, house, or room), wall material, roof material, flooring material, geographic location (federative unit, rural or urban area, and type of area), availability of a refrigerator, availability of garbage collection services, presence of a pet, presence of domestic help, and household per capita income.

A logistic regression model was applied, where the probability of being absent from activities due to diarrhea is a binary variable with values (1) for absence and (0) for no absence. The logistic regression model is described by equation (6):

$$(6) \qquad P(y=1 \mid x_1, x_2, ..., x_k) = G(\beta_0 + \beta_1 x_1 + ... + \beta_k x_k)$$

where y represents the dependent variable (probability of absence due to diarrhea), xj are the explanatory variables, with j = 1, 2,..., k, f3 are the coefficients quantifying the relationships between these variables and the dependent variable. G is a function that takes strictly positive values between zero and one: 0 < G(z) < 1, for all real numbers z. This ensures that the estimated probabilities lie strictly between zero and one.

The model estimated to analyze the effect of sanitation on the probability of absence from routine activities due to diarrhea or vomiting produced highly satisfactory results. The greater the share of the population with access to treated water and sewage collection networks, the lower the probability of absence from routine activities due to diarrhea or vomiting. The coefficients of these two variables are presented in Table A.M.1. The remaining control variables showed the expected signs and are statistically significant.

Table A.M.1
Regression Results for Absence due to Diarrhea, Brazil, 2019

	Coefficient	Standard Error	*p* -value	Odds Ratio
Piped water in at least one room	-0,0130	0,0052	0,0121	0,9871
Access to the treated water network	-0,0230	0,0049	0,0000	0,9773
Access to the sewage network	-0,0300	0,0024	0,0000	0,9704
Availability of an exclusive bathroom	-0,1036	0,0075	0,0000	0,9015

Sources: PNS (IBGE, 2020).
Prepared by: Ex Ante Consultoria Econômica.

3. SANITATION AND RESPIRATORY DISEASE MORBIDITY

The analysis of the effects of sanitation on the incidence of respiratory diseases was based on the cross-referencing of information on work absences due to respiratory diseases, access to sewage, access to treated water, availability of a private bathroom, and socioeconomic indicators. To calculate these effects, data from the 2019 National Health Survey conducted by IBGE were used. The socioeconomic indicators used in the econometric models are: (i) information about individuals: age, gender, and whether they study or work; and (ii) information about the household: type of dwelling (apartment, house, or room), wall material, roof material, flooring material, geographic location (federative unit, rural or urban area, and type of area), availability of a refrigerator, availability of garbage collection services, presence of a pet, presence of domestic help, and household per capita income.

A logistic regression model was applied, where the probability of being absent from activities due to respiratory diseases is a binary variable with values (1) for absence and (0) for no absence. The logistic regression model is described by equation (7):

$$(7) \qquad P(y=1 \mid x_1, x_2, ..., x_k) = G(\beta_0 + \beta_1 x_1 + ... + \beta_k x_k)$$

where y represents the dependent variable (probability of absence due to respiratory diseases), xj are the explanatory variables, with j = 1, 2,..., k, β are the coefficients quantifying the relationships between these variables and the dependent variable. G is a function that takes strictly positive values between zero and one: $0 < G(z) < 1$, for all real numbers z. This ensures that the estimated probabilities lie strictly between zero and one.

The model estimated to analyze the effect of sanitation on the probability of absence from routine activities due to respiratory diseases produced highly satisfactory results. The greater the share of the population with access to treated water and sewage collection networks, the lower the probability of absence from routine activities due to respiratory diseases. The coefficients of these two variables are presented in Table A.M.2. The remaining control variables showed the expected signs and are statistically significant.

Table A.M.2
Regression Results for Absence due to Respiratory Diseases, Brazil, 2019

	Coefficient	Standard Error	*p*-value	Odds Ratio
Piped water in at least one room	-0,0641	0,0033	0,0000	0,9379
Access to the treated water network	-0,2885	0,0036	0,0000	0,7494
Access to the sewage network	-0,0030	0,0015	0,0492	0,9970
Availability of an exclusive bathroom	-0,0376	0,0050	0,0000	0,9631

Sources: PNS (IBGE, 2020).
Prepared by: Ex Ante Consultoria Econômica.

4. SANITATION AND PRODUCTIVITY

The analysis of the effects of sanitation on labor income was based on the combination of hourly wage data with information on access to sewage, access to treated water, availability of a bathroom in the residence, and a broad set of socioeconomic control indicators. The database used for this evaluation was the 2023 Continuous National Household Sample Survey. The control variables were: (i) age; (ii) age squared; (iii) gender; (iv) color or race; (v) education level; (vi) economic activity sector; (vii) occupational position; (viii) household condition; (ix) wall material of the residence; (x) roofing material of the residence; (xi) garbage collection system; (xii) state of residence; (xiii) area of residence (rural or urban); and (xiv) place of residence (capital city, metropolitan regions, or interior regions).

$$(8) \quad \ln y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + m.$$

Two econometric models were estimated: the first, using an ordinary least squares (OLS) estimator; and the second, a linear model estimated by maximum likelihood with correction for sample selection bias, in which the dependent variable, average hourly wage, was transformed into ln for better statistical fit. The regression results are presented in Table A.M.3. The estimated models produced highly satisfactory results. The greater the share of the population with access to sewage services, the higher the labor income. Access to treated water also positively affects workers' income. The absence of a bathroom in the residence reduces the expected average hourly wage.

Table A.M.3
Productivity Regression, Brazil, 2023

OLS	Coefficient	Standard Error	*p*-value
Access to treated water*	0,0425	0,0002	0,0000
Access to the sewage network	0,0360	0,0002	0,0000
Availability of the bathroom	0,2183	0,0007	0,0000
Sample Selection Correction			
Access to treated water*	0,0566	0,0002	0,0000
Access to the sewage network	0,0575	0,0002	0,0000
Availability of the bathroom	0,2486	0,0007	0,0000

Source: PNADC 2023 (IBGE, 2024). Prepared by: Ex Ante Consultoria Econômica.
(*) Daily access to water supplied through the public network.

5. SANITATION AND SCHOOL DELAY

The analysis of the effects of sanitation on school performance was based on the dependent variable school delay, constructed from the difference between the individual's years of schooling and the grade level they should be attending. This analysis was applied only to individuals of school age, that is, children and adolescents aged 5 to 20 years. The database used was the 2023 Continuous National Household Sample Survey, and the control variables were: (i) gender; (ii) self-reported color or race; (iii) wall material; (iv) roofing material of the residence; (v) garbage collection system; (vi) state of residence; (vii) area of residence (rural or urban); (viii) place of residence (capital city, metropolitan regions, or interior regions); and (ix) household per capita income (in ln).

The econometric model used was a Poisson model, which is applied when the dependent variable is a count variable, such as the number of days absent from activities due to diarrhea or vomiting. This technique models the expected value as an exponential function according to equation (9):

$$(9) \quad E(y \mid x_1, x_2, ..., x_k) = \exp(\beta_0 + \beta_1 x_1 + ... + \beta_k x_k)$$

Since exp(.) is always positive, equation (9) ensures that the predicted values of y will always be positive. For inference processes using the Poisson model, see Wooldridge (2006).

The estimated model produced highly satisfactory results. The greater the share of the population with access to sewage services, the lower the school delay; in other words, access to this service contributes positively to school performance. Access to treated water also had the same effect, contributing to a reduction in school delay. The remaining control variables showed the expected signs and are statistically significant.

Table A.M.4
School Delay Regression, Brazil, 2023

	Coefficient	Standard Error	p-value
Access to treated water*	-0,0043	0,0003	0,0000
Access to the sewage network	-0,0217	0,0003	0,0000
Availability of the bathroom	-0,1682	0,0007	0,0000

Source: PNADC 2023 (IBGE, 2024). Prepared by: Ex Ante Consultoria Econômica.
(*) Daily access to water supplied through the public network.

6. SANITATION AND SCHOOL PERFORMANCE – ENEM

The analysis of the effects of sanitation on school performance was based on the combination of ENEM 2023 test scores with information on the availability of a bathroom in the home and a broad set of socioeconomic control indicators. The analyzed population was between 19 and 29 years of age. The database used for this evaluation was the ENEM 2023 microdata provided by INEP. The control variables were: (i) age; (ii) gender; (iii) color or race; (iv) father's education level; (v) mother's education level; (vi) household income class; (vii) availability of a washing machine; (viii) availability of a dishwasher; and (ix) place of residence (capital city, metropolitan regions, or interior regions).

The econometric models used were linear equations estimated by OLS, in which the dependent variables are the test scores (Di) for: natural sciences (NS), human sciences (HS), language and codes (LC), mathematics (MT), and essay writing (EW). A regression was also estimated for the average score across the five tests (average). The following equation describes the statistical model:

$$(10)\quad D_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + m,\ i = \text{CN, CH, LC, MT, RE, Média.}$$

The regression results are presented in Table A.M.5. The estimated models produced highly satisfactory results. As expected, the absence of a bathroom in the candidate's home reduces their scores across all ENEM tests.

Table A.M.5
School Performance Regression in ENEM, Brazil, 2023

Partial effect of the presence of a bathroom in the home	Coefficient	standard error	p-value
Human Sciences	-6,4880	1,0808	0,0001
Natural Sciences	-6,4880	1,0808	0,0001
Language and Codes	-17,5560	1,1543	0,0003
Mathematics	-11,9746	1,7092	0,0001
Written Essay	-40,5755	3,2287	0,0002
Average	**-17,8869**	**1,2832**	**0,0003**

Source: INEP.
Prepared by: Ex Ante Consultoria Econômica.

7. SANITATION AND REAL ESTATE APPRECIATION

The analysis of the effects of sanitation on property values was based on microeconomic data on rental values, access to sewage, and other socioeconomic indicators of Brazilian residences. The database used was the 2023 Continuous National Household Sample Survey, which contains information on Brazilian households in both urban and rural areas across all regions of the country. Equation (9) describes the statistical model, in which the variable being explained is the monthly real estate income (estimated by rental value). Several variables were used to explain the behavior of this variable: (i) type of residence (apartment or house); (ii) predominant material of exterior walls; (iii) predominant roofing material; (iv) predominant flooring material; (v) number of rooms; (vi) number of bedrooms; (vii) existence of regular garbage collection at the residence; (viii) state of residence; (ix) area of residence (rural or urban); (x) place of residence (capital city, metropolitan regions, or interior regions); (xi) access to treated water; (xii) access to the public sewage network; and (xiii) availability of a bathroom in the residence.

The econometric model was estimated by ordinary least squares (OLS) to assess the effect of a broad set of variables on the value of real estate income (in ln scale).

$$(11)\quad \ln y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + m.$$

The estimated model presented very significant results, which shows a positive influence of sanitation on property values and on the income that can be derived from these assets. Considering two identical properties, one with sanitation access and one without, the property with access to the public sewage network is expected to have a higher rental value than the one without sewage collection access. Access to treated water also has a positive effect on rental value, and the presence of a bathroom increases real estate income, in accordance with Table A.M.6. The remaining control variables also produced statistically significant coefficients with the expected signs.

Table A.M.6
Real Estate Appreciation Regression, Brazil, 2023

OLS	Coefficient	Standard Error	*p*-value
Access to treated water*	0,0686	0,0005	0,0000
Access to the sewage network	0,0502	0,0004	0,0000
Availability of the bathroom	0,1846	0,0024	0,0000

Source: PNADC 2023 (IBGE, 2024). Prepared by: Ex Ante Consultoria Econômica.
(*) Daily access to water supplied through the public network.

8. SANITATION AND TOURISM

The analysis of the effects of sanitation on employment in the tourism sector was based on a logistic regression model that considers, on one hand, the categorical variable of whether or not the individual works in the tourism sector, and on the other, access to water supply and sewage collection services, along with a set of socioeconomic variables. The following economic activities were considered: accommodation and food services; recreational, cultural, and sports activities; travel agencies; passenger land transportation; and air transportation. The database used was the 2023 Continuous National Household Sample Survey, and the explanatory variables included: (i) age and age squared; (ii) gender; (iii) color or race; (iv) education level; (v) predominant exterior wall material; (vi) predominant roofing material; (viii) existence of regular garbage collection at the residence; (ix) state of residence; (x) area of residence (rural or urban); (xi) place of residence (capital city, metropolitan regions, or interior regions); (xii) access to treated water; (xiii) access to the public sewage network; and (xiv) availability of a bathroom in the residence. The regression results are presented in Table A.M.7. The logistic regression model used is described by equation (12):

$$(12) \quad P(y=1 \mid x_1, x_2, ..., x_k) = G(\beta_0 + \beta_1 x_1 + ... + \beta_k x_k)$$

The estimated model produced highly satisfactory results. The greater the share of the population with access to sewage services, the higher the number of workers in the tourism sector. Access to treated water also had the same effect, contributing to an increase in tourism sector employment. The availability of a bathroom also showed a strong coefficient. The remaining control variables showed the expected signs and are statistically significant.

Table A.M.7
Tourism Employment Regression, Brazil, 2023

	Coefficient	Standard Error	*p*-value	Odds Ratio
Access to the treated water network	0,0407	0,0013	0,0000	1,0415
Access to the sewage network	0,0406	0,0011	0,0000	1,0415
Availability of an exclusive bathroom	0,1065	0,0057	0,0000	1,1124

Source: PNADC 2023 (IBGE, 2024). Prepared by: Ex Ante Consultoria Econômica.
(*) Daily access to water supplied through the public network.

9. METHODOLOGY FOR CALCULATING THE SANITATION COST-BENEFIT BALANCE

Annex 9 describes the steps for estimating the cost-benefit balance costs. The estimation methodology takes into account the social benefits and costs of sanitation investments and operations. Among the benefits are the externalities: (a1) reduction in healthcare costs, (a2) increase in labor productivity, (a3) increase in income due to real estate appreciation, and (a4) increase in tourism income. In addition, there is income generated by investments (b1), income generated by revenue expansion (b2), and taxes on consumption and production collected from these two activities (b3). Social costs include: the value of investments (d1) and the increase in household expenditures (d2).

All values are expressed in constant 2024 prices, based on the unit price of water and sewage services (SNIS) and the unit costs of sanitation works, which were estimated using data from the Annual Survey of the Construction Industry and the National System of Construction Costs (SINAPI), with weights for materials, labor, and services estimated by the 2023 Annual Survey of the Construction Industry (IBGE). The constant values were converted to present values in 2024.

Table A.M. 8 illustrates the sanitation benefit and cost flows in Brazil from 2005 to 2023, in BRL billion. Each column presents one of the flows, and the last column shows the balance. The values for each year are shown in the rows. The last row provides the sum for the entire period. In addition to the benefit and cost estimates, there are subtotals for each group. The letters indicate the formulas that make up the subtotals, totals, and balance.

The externalities were calculated based on the econometric models described in Methodological Annexes 2 to 8 and the sanitation coverage rates for each specific period. It should be noted that the flows represent interannual differences between the estimates for two years. For example, in the case of variable a2, the value for 2006 refers to the difference in labor income between 2006 and 2007 that can be attributed to changes in the water and sewage service coverage rates. For all variables from a1 to a4, the portions attributable to sanitation are calculated through the partial derivatives of the econometric models and the variation in coverage rates.

The incomes generated by investment and by revenue growth from sanitation operations are calculated by applying the income multipliers from Tables 3.1 to 3.4, which were calculated according to the methodology described in Methodological Annex 1. The tax revenue comes from previous estimates and the tax burden presented in Table 3.5.

The investment cost (d1) is the present value of the amounts actually invested. The increase in household expenditures is calculated based on the interannual difference in the municipalities' direct and indirect operational revenues, as published by SNIS.

The following describes the procedures adopted to obtain the current values used to calculate the constant and present values of the variables in the projection of the cost-benefit balance of sanitation universalization between 2024 and 2040.

a1. The value of healthcare savings in each area (capital cities, metropolitan regions, and interior municipalities)

corresponds to the sum of expenses related to hours not worked due to absences caused by diarrhea or vomiting, or by respiratory diseases, along with hospitalization costs for these diseases. To estimate the expenses related to hours not worked, the projected number of people absent in 2040 was used. This number was estimated by multiplying the projected 2040 population by the labor force participation rate, and by the absence probabilities estimated in Methodological Annexes 2 and 3. The probability of absence in 2040 was estimated by imputing basic sanitation access (water and sewage) for all residents who did not have access to sanitation in 2022. The number of absent individuals was then multiplied by the average number of hours missed and by the average hourly wage in each area, according to IBGE statistics. The reduction in hospitalization costs was calculated proportionally to the expected reduction in work absences.

a2. The value of the productivity increase corresponds to the expected income increase for the entire employed population in each area in 2040. To estimate the average income with sanitation universalization, basic sanitation access (water and sewage) was imputed for all workers in areas that lacked sanitation access in 2022. The productivity increase was calculated as the difference between aggregate income in 2022 and the income that would prevail in 2040 if the access rates to the system that existed in 2022 were expanded.

a3. The value of the real estate income increase corresponds to the expected increase in real estate income for all residential properties in the areas in 2040. To estimate aggregate real estate income with sanitation universalization, the equation from Methodological Annex 7 was applied, imputing basic sanitation access (water and sewage) for all households that lacked sanitation access in 2022. The real estate income increase was calculated as the difference between the aggregate real estate income and the income that would prevail in 2040 with universalization.

a4. The increase in tourism income corresponds to the expected increase in income for the sector in 2040 due to sanitation universalization. To estimate aggregate tourism income with sanitation universalization, equations combining average income and the probability of working in the tourism sector were used, which calculate the average labor income in the tourism sector and the probability of a worker being employed in the sector. The calculations were performed by imputing basic sanitation access (water and sewage) for all workers in areas that lacked sanitation access in 2022. The increase in labor income in the sector was calculated as the difference between the current average income and the income that would prevail in 2040 with universalization. With the expansion of sanitation, the number of people employed in the sector also changes.

b1. The income generated by sanitation investment in each year corresponds to the multiplication of the projected investment value for that year by the direct, indirect, and induced income coefficient for sanitation works, estimated using the methodology presented in Methodological Annex 1.

b2. The income generated by the increase in operations corresponds to the multiplication of the projected revenue increase between 2024 and 2040 by the direct, indirect, and induced income coefficient for water distribution and sewage collection and treatment activities, estimated using the methodology presented in Methodological Annex 1.

b3. The tax revenue comes from the previous estimates (b1 and b2) and the tax burden presented in Table 3.5.

d1. The cost of sanitation investment in each year corresponds to the projected investment value for each year between 2024 and 2040.

d2. The increase in household expenditures in each year corresponds to the projected revenue increase between 2024 and 2040.

The annual flows in present values are summed to estimate the costs and benefits in each area. The following tables provide an example of the estimates for the period from 2005 to 2023 for Brazil as a whole.

Table A.M.8
Benefit and cost balance flows of sanitation expansion in the Legal Amazon, 2005 to 2023, in BRL million*

	Reduction in healthcare costs	Increase in labor productivity	Income from real estate appreciation	Tourism income	Subtotal externalities (A)	Income generated by investment	Income generated by increased operations
2005	827,806	4.862,849	43,853	454,122	6.188,630	998,635	154,357
2006	751,015	4.441,826	84,270	412,081	5.689,193	1.572,016	460,710
2007	679,046	4.041,407	121,453	372,638	5.214,545	1.666,629	1.089,087
2008	608,517	3.660,742	155,594	335,655	4.760,508	1.947,440	1.330,079
2009	584,407	3.299,015	186,873	300,998	4.371,292	2.339,715	1.620,700
2010	560,286	2.955,439	215,462	268,542	3.999,729	2.250,886	3.209,350
2011	471,940	2.629,259	241,524	238,168	3.580,891	1.981,624	3.504,179
2012	398,508	2.319,747	265,214	209,763	3.193,232	2.871,960	3.871,144
2013	348,353	2.026,203	286,677	183,219	2.844,452	2.906,578	4.178,127
2014	295,352	1.747,956	306,051	158,434	2.507,792	2.695,098	5.153,368
2015	227,091	1.484,357	323,468	135,310	2.170,226	2.035,772	5.627,996
2016	186,658	1.234,786	339,049	113,755	1.874,248	2.191,993	6.682,592
2017	147,829	998,643	352,914	93,682	1.593,069	2.024,693	7.148,769
2018	114,894	904,174	365,172	75,008	1.459,249	2.630,596	7.540,972
2019	92,704	803,711	375,928	57,655	1.329,997	2.645,318	8.881,505
2020	29,341	775,355	385,280	41,546	1.231,522	2.873,101	6.340,501
2021	26,988	602,783	393,323	26,612	1.049,705	2.479,903	1.459,240
2022	2,474	301,391	400,145	12,784	716,795	1.994,091	1.803,799
2023	0,000	200,928	225,070	188,811	614,809	4.963,415	717,350
Total	6.353,210	39.290,570	5.067,322	3.678,782	54.389,883	45.069,462	70.773,826

Continuation

Continuation

	Taxes related to production**	Subtotal income (B)	Total benefits (C=A+B)	Investment cost	Increase in household expenses	Total costs (D)	Balance (E=C+D)
2005	67,348	1.220,339	7.408,969	-788,958	-109,973	-898,931	6.510,038
2006	116,890	2.149,615	7.838,808	-1.233,662	-328,236	-1.561,897	6.276,911
2007	153,923	2.909,639	8.124,184	-1.312,017	-775,928	-2.087,945	6.036,239
2008	182,728	3.460,247	8.220,755	-1.529,328	-947,624	-2.476,952	5.743,803
2009	220,669	4.181,083	8.552,376	-1.829,617	-1.154,679	-2.984,296	5.568,080
2010	294,704	5.754,940	9.754,669	-1.730,355	-2.286,524	-4.016,879	5.737,791
2011	293,347	5.779,150	9.360,042	-1.481,582	-2.496,577	-3.978,159	5.381,883
2012	364,846	7.107,949	10.301,182	-2.255,374	-2.758,023	-5.013,397	5.287,785
2013	382,244	7.466,949	10.311,401	-2.246,011	-2.976,735	-5.222,747	5.088,655
2014	418,319	8.266,786	10.774,578	-2.111,661	-3.671,552	-5.783,213	4.991,365
2015	402,648	8.066,417	10.236,642	-1.605,096	-4.009,705	-5.614,801	4.621,841
2016	464,646	9.339,230	11.213,478	-1.717,365	-4.761,058	-6.478,423	4.735,054
2017	477,936	9.651,398	11.244,467	-1.557,387	-5.093,190	-6.650,577	4.593,890
2018	533,708	10.705,277	12.164,526	-2.069,262	-5.372,618	-7.441,880	4.722,646
2019	601,535	12.128,358	13.458,355	-2.110,923	-6.327,690	-8.438,612	5.019,743
2020	488,237	9.701,839	10.933,361	-2.247,132	-4.517,334	-6.764,466	4.168,896
2021	220,978	4.160,121	5.209,826	-1.966,201	-1.039,646	-3.005,847	2.203,979
2022	209,172	4.007,062	4.723,857	-1.569,122	-1.285,129	-2.854,251	1.869,606
2023	332,243	6.013,008	6.627,817	-3.843,511	-511,081	-4.354,593	2.273,224
Total	6.226,121	122.069,409	176.459,292	-35.204,565	-50.423,299	-85.627,864	90.831,428

Source: Ex Ante Consultoria Econômica. (*) present values at 2024 prices.
(**) from sanitation investments and operations and real estate activities.

THE SHARE OF THE POPULATION WITH ACCESS TO TREATED WATER DISTRIBUTION SERVICES IN THE LEGAL AMAZON INCREASED FROM 50.8% IN 2000 TO 68.4% IN 2022. THIS MEANT THAT, OVER THOSE 22 YEARS, ABOUT 8 MILLION PEOPLE GAINED ACCESS TO THIS FUNDAMENTAL AND HUMANITARIAN SERVICE. THE SHARE OF THE REGION'S POPULATION WITH ACCESS TO SEWAGE COLLECTION SERVICES ROSE FROM 10.2% TO 23.2% BETWEEN 2000 AND 2022. MORE THAN 4 MILLION PEOPLE WERE INCORPORATED INTO THE COLLECTION SYSTEM. HOWEVER, ABOUT 22 MILLION PEOPLE STILL LACK ACCESS TO THIS BASIC SANITATION SERVICE IN THE LEGAL AMAZON.

GIVEN THE SLOW PROGRESS OF BASIC SANITATION IN THE REGION, THE CHALLENGE OF UNIVERSAL ACCESS IN THE LEGAL AMAZON REMAINS IMMENSE. THIS STUDY ANALYZES THE EVOLUTION OF SANITATION IN THE REGION BETWEEN 2000 AND 2022 AND ITS IMPACTS ON SOCIETY, FOCUSING MAINLY ON THE EFFECTS ON THE ECONOMY. THE STUDY ALSO PROVIDES A BALANCE OF THE SOCIAL AND ECONOMIC BENEFITS THAT THE POPULATION OF THE LEGAL AMAZON WILL GAIN WITH UNIVERSAL ACCESS TO SANITATION BY 2040.

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