

# Environmental health and development in legal amazon: socio-economic, environmental and sanitary indicators, challenges and perspectives

Saúde ambiental e desenvolvimento na Amazônia legal: indicadores socioeconômicos, ambientais e sanitários, desafios e perspectivas

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## **Abstract**

This article aimed to discuss the processes of determining the environmental situation in the states that are part of the Brazilian Legal Amazon, based on the analysis of socio-economic, environmental and sanitary indicators. The indicators showed a very dynamic and heterogeneous region, with a growing population mostly concentrated in urban areas, combining economic growth and environmental degradation associated with a rapid and precarious urbanization process, and with development projects focused on the exploitation of natural resources. The result is a complex picture of health problems, with the presence of infectious and parasitic diseases related to severe environmental changes and poor conditions of life, caused mainly by inequalities in social and economic indicators that produce vulnerabilities and negative effects on the environmental and sanitary context.

**Keywords:** Living Conditions; Environmental Degradation; Environmental Health Indicators; Environmental Health.

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## Resumo

Este artigo tem por objetivo discutir os processos de determinação socioambiental nos estados que compõem a Amazônia Legal, com base na análise de indicadores socioeconômicos, ambientais e sanitários. Nesse sentido, os resultados demonstraram uma região dinâmica e muito heterogênea, com uma população crescente e concentrada principalmente em áreas urbanas, combinando crescimento econômico e degradação ambiental a um rápido e precário processo de urbanização e aos projetos de desenvolvimento voltados para a exploração de recursos naturais. O resultado é um quadro complexo de problemas de saúde, com expressividade das doenças infecciosas e parasitárias relacionadas às intensas mudanças ambientais e às difíceis condições de vida, decorrentes principalmente da persistência de imensas desigualdades nos indicadores sociais e econômicos. Tais vulnerabilidades produzem efeitos negativos no quadro ambiental e sanitário da região.

**Palavras-chave:** Condições de Vida; Degradação Ambiental; Indicadores em Saúde Ambiental; Saúde Ambiental.

## Introduction

The technical-scientific debate about the relationship between health, environment, and development in the Brazilian Amazon, available in scientific journals, is still very limited, despite the significant amount of articles that discuss the ecological, biological, and social aspects of the region in question. In general, the articles available in these journals on health in the Amazon relate to clinical or epidemiological endemic diseases (such as malaria, dengue, leishmaniasis, and viral hepatitis). On the other hand, the articles relating to the environment and development are restricted to disciplinary approaches on biodiversity, land use, deforestation, and sustainable development (Freitas; Giatti, 2009; Confalonieri, 2005).

The studies that seek to multidisciplinary articulate the themes “health, environment and development” in the Brazilian Amazon are rare. From electronic portals such as Pub-Med and SciELO, which cover a significant production of biomedical and public health essays, only three articles have been found on the subject (Briceño-León, 2007; Vicentin et al, 2003; Freitas; Giatti, 2009).

Starting from the hypothesis that the economic model of development adopted in the Brazilian Amazon has produced significant environmental changes and failed to positively impact the social and health indicators, this study aims to discuss the processes of determining the social and environmental situation in the states that make up the Legal Amazon, from their available socioeconomic, environmental, and health indicators. Therefore, the socio-environmental determination corresponds to the processes that, at the level of macropolitics, shape the structures of production (goods and services), and distributions of wealth, simultaneously conforming environmental processes (cycles of climate, soil and waters, for example) and the health status of populations (Sobral; Freitas, 2010).

The choice of this region as the object of analysis is justified for presenting environmental (climate, ecosystems, and biodiversity) and demographic (sociodiversity with low density and population concentrated in the cities) peculiarities that, combined with economic processes, such as extensive

agriculture, livestock, mining, hydroelectric power plants and industries, produce effects on health conditions of populations related to its development model (Freitas; Giatti, 2009).

## Material and methods

This study is an analysis of processes to determine the socio-environmental and health situation (social, economic, cultural and environmental factors, among others, that influence health problems in the population), as Sobral and Freitas (2010) stated, with the use of quantifiable variables (indicators) and literature review.

The delimitation of the study area comprised the total area of the 9 states which make up the Legal Amazon (Acre, Amapá, Amazonas, Mato Grosso, Pará, Rondônia, Roraima, Tocantins, and Maranhão). After this step, a bibliographical research was performed on SciELO and MEDLINE (PubMed) covering the last 10 years, using the descriptors (search terms) “health, environment and development” and “Amazon”. The search made up a review that identified the themes that have been prioritized in the research on the relations between health, environment, and development, to contextualize and discuss the indicators.

Subsequently, socioeconomic, environmental and health data and indicators of the region were collected. The organization of the data and the indicators aimed to show the possible relationships and interactions between socioeconomic determinants, the environmental changes and their impacts on the exposure and direct effects to the health of the populations (Freitas; Giatti, 2009).

Data collection was carried out electronically via websites provided by Brazilian public institutions. The health indicators were collected at *Rede Intergerencial de Informações para o Setor Saúde* (Inter-Managerial Information Network for the Health Industry - RIPSAs), and the economic and social indicators in the publications of the *Instituto Brasileiro de Geografia e Estatística* (Brazilian Institute of Geography and Statistics - IBGE), UNDP (United Nations Development Program), and *Instituto Nacional de Pesquisas Espaciais* (National In-

stitute for Space Research - INPE). The organization of data and the discussion of the study started off from the central hypothesis of the study presented in the introduction, observing the developments and comparisons of the indicators of the Brazilian Amazon (and its states) with the indicators achieved in the country, as well as the possibilities of crossing the data. The main reference when collecting the indicators was the year of the last Population Census (2010) held in the country (IBGE, 2010), aiming at building a frame with separate data on its origin, however close in relation to the collection years.

Finally, it is important to consider that, if on the one hand, the systematization and analysis of secondary data and the construction of indicators have been widely used for global analyses (of countries or even regions), allowing for a broader view about certain topics, on the other geographic spaces and public policies present limitations. The first limitation is that each piece of data used was collected and built from different patterns of quality, validity, reliability, coverage, sensitivity, and specificity, resulting from a context of great local variability in the ability to collect data, which interferes in the quality of the data. The second one is that, even though the limits indicated previously did not exist, each indicator is, by nature, a reduction of the complexity to a single one-dimensional value (Van Bellen, 2005).

This reality reduction feature, however, is the synthesis capability represented by the indicators, which contribute fundamentally to make studies between magnified scales possible and enable multidisciplinary analyses (Van Bellen, 2005; Corvalán et al., 2000). In Brazil, there is a wide tradition in the production of socio-economic and demographic indicators, as well as health indicators. Some environmental indicators, such as those that require environmental quality monitoring, are newer and have more limitations. However, in this study, even some environmental indicators, such as those related to access to water and sanitation, are produced based in the census, therefore having better quality, periodicity and nationwide reach (IBGE, 2012; Freitas; Giatti, 2009; Corvalán et al., 2000).

## Results

### Socioeconomic indicators

In the period of 2002 to 2011, with the exception of the state of Amazonas, the states of the Legal Amazon presented more than 200% increment in GDP (Gross Domestic Product). In the same period, the states of the Amazon increased their contribution to the national GDP, rising from 7% (2002) to 13% (2011).

In 2011, the state of Mato Grosso remained with the highest GDP per capita of the Amazon. For that

indicator, the negative highlight was the state of Maranhão, which obtained the lowest GDP per capita, with the worst performance of the Country, despite being the 15<sup>th</sup> largest GDP and having the tenth largest Brazilian population. The other states showed GDP per capita below the national average (Table 1). It is important to add that the considerable amounts of GDP affected by the Amazonian states reflect the significant growth of the Brazilian economy between the years, even in the face of the global economic crisis intensified during the period (IBGE, 2013).

**Table 1 – Socioeconomic indicators. Brazil, Legal Amazon**

Region	GDP 2002 BRL 1,000,000	GDP 2011 BRL 1,000,000	Growth in GDP volume in the period from 2002 to 2011 %	GDP per capita 2011 BRL	Extreme poverty index 2000 %	Extreme poverty index 2010 %	Decrease in the extreme poverty index 2000-2010 %
Brazil	1,346,028	4,143,013	207.8	21,535.65	12.48	6.62	-47.0%
Amazon Amazon	97,096	542,841	459.1	21,019.26	20.76	13.00	-37.4%
Rondônia	7,284	27839	282.2	17,659.33	12.60	6.39	-49.3%
Acre	2,259	8,794	289.3	11,782.59	22.99	15.59	-32.2%
Amazonas	25,030	64,555	157.9	18,244.30	17.40	9.93	-42.9%
Roraima	1,488	6,951	367.1	15,105.86	16.53	15.66	-5.3%
Pará	25,530	88,371	246.1	11,493.73	22.89	15.90	-30.5%
Amapá	2,652	8,968	238.2	13,105.24	27.13	16.43	-39.4%
Tocantins	3,545	18,059	409.4	12,891.19	22.28	10.21	-54.2%
Maranhão	11,420	52,187	357.0	7,852.71	37.21	22.47	-39.6%
Mato Grosso	17,888	71,418	299.3	23,218.24	7.83	4.41	-43.7%

Source: RIPSA (2013); UNDP (2013). \* GDP in current amounts.

Between 2000 and 2010, extreme poverty (percentage of the population with average home income per capita up to 25% of the monthly minimum wage) of the Legal Amazon performed above the national average, despite showing a decrease of 37.4% below the national average. In the year of 2010, the state of Mato Grosso reached the lowest percentage in that indicator. Now, the state of Maranhão remained with the highest rate of

extreme poverty in the Amazon and the country (Table 1).

In the same period, the HDI (Human Development Index) of the Legal Amazon had an increase of 0.143 points, surpassing the growth of Brazil's HDI (Table 2). It is worth pointing out that the states of the Amazon remained among the worst performances in the country. For example, the state of Maranhão presented the second worst HDI

among the Brazilian states in 2010, even though it had an increase of 0.163 points in that indicator in the period studied (UNDP, 2013).

For the illiteracy rate of the population with 18 years old or older, the Amazonian states showed significant declines, with amounts above 20%

(Table 2). The most unfavorable performances in the national ranking were achieved by the states of Maranhão (4<sup>th</sup> position) and Acre (7<sup>th</sup> position). The states also showed adverse results above the national and Legal Amazon averages (Table 2) (UNDP, 2013).

**Table 2 – Human development and education indicators. Brazil, Legal Amazon**

Brazil	HDI 2000	HDI 2010	HDI growth 2000-2010	Illiteracy rate - 18 y.o. or more 2000 (%)	Illiteracy rate - 18 y.o. or more 2010 (%)	Illiteracy rate decline 2000-2010 (%)
Brazil	0.612	0.727	0.115	13.8	10.2	-26.3%
Amazon Amazon	0.540	0.683	0.143	17.9	12.9	-28.0%
Rondônia	0.537	0.690	0.153	13.6	9.4	-30.9%
Acre	0.517	0.663	0.146	25.4	17.8	-30.1%
Amazonas	0.515	0.674	0.159	16.2	10.5	-35.3%
Roraima	0.598	0.707	0.109	14.0	11.0	-21.2%
Pará	0.518	0.646	0.128	17.4	12.6	-27.6%
Amapá	0.577	0.708	0.131	12.9	9.1	-29.3%
Tocantins	0.525	0.699	0.174	19.6	14.1	-27.9%
Maranhão	0.476	0.639	0.163	29.6	22.5	-24.1%
Mato Grosso	0.601	0.725	0.124	12.6	9.1	-28.2%

Source: RIPSAs (2013); UNDP (2013).

### Environmental and sanitary indicators

In the space that surrounds the Southern and Eastern Amazon (the states of Rondônia, Mato Grosso, Tocantins, Maranhão, and Pará) the fire outbreaks, the accumulated deforestation, and the construction of highways are expanded, as well as the expansion of crop acreage and the intensification of the consumption of pesticides (INPE, 2013; IBGE, 2012). For these characteristics, Becker (2009) named the space as the “arc of fire”. Regarding the consumption of pesticides, the indexes reached using these substances in the region were expressive, corresponding to 18% of the national total. According to the latest figures released by the IBGE (year 2009), the state of Mato Grosso achieved the highest national index of consumption of pesticides per hectare of acreage in the Legal Amazon (IBGE, 2012) (Table 3).

According to the indicators, the growth data for the crop and pasture areas over the natural areas, the hotspots, and the accumulated deforestation in the Amazon have reached the highest indicators in the same “arc of fire”, with a clear coincidence between the expansion of extensive farming and the deforestation with burning events and the use of pesticides (Table 3). When crossing environmental indicators (rate of deforestation and use of pesticides) with social indicators (extreme poverty and evolution of HDI) we observed the following discrepancies between the indicators in the periods studied: 1) The state of Mato Grosso, which reached the third largest GDP and the higher HDI of the Amazon at the end of the studied period, achieved the second highest rate of deforestation and use of pesticides, in addition to the second smaller development of the HDI; 2) The state of Pará, which reached the highest GDP, was the third state in the region with the highest percentage of extremely

poor population, and presented the second worst HDI and the fourth lower development in this indicator,

even getting the third highest rate of deforestation (Tables 1, 2, and 3).

**Table 3 – Environmental and sanitary indicators. Brazil, Legal Amazon (2006 and 2013)**

Region/State*	Residential coverage of water utility 2010 %	Residential coverage of sewage utility 2010 %	Residential coverage of garbage collection 2010 %	Accumulated deforestation rate of territorial surface 1991 to 2010 %	Participation of the land in agricultural use in territorial areas 2006* %	Consumption and use of agro-chemicals and allied products 2009 kg/ha	Hotspots and burnings 2000 to 2009 unit
Brazil	83%	55%	87%	-	26.47%	3.60	185,5412
Amazon Amazon	60%	14%	71%	7%	13.41%	1.98	126.5856
Rondônia	39%	6%	73%	20%	22.60%	2.70	93,884
Acre	47%	24%	75%	7%	8.02%	1.10	11,487
Amazonas	65%	26%	79%	1%	1.09%	0.20	21,767
Roraima	81%	15%	79%	2%	3.76%	1.80	17,196
Pará	48%	10%	71%	9%	10.44%	1.00	335,609
Amapá	55%	7%	89%	1%	2.98%	2.70	6,876
Tocantins	79%	13%	77%	2%	31.69%	2.10	122,537
Maranhão	66%	12%	56%	5%	24.94%	2.00	213,208
Mato Grosso	75%	19%	83%	13%	31.61%	4.30	443,292

Source: INPE (2013); IBGE (2010). \*Data from the last Agricultural Census (2006) performed by the IBGE.

Concerning access to basic sanitation services (water supply, sanitary sewage systems, and solid waste disposal, collection, and treatment), the Amazonian states followed the national trend, with positive increments in the period from 2000 to 2010. In 2010, the states of Rondônia, Acre and Pará reached the lowest indicators of access to water supply through the main water network (Table 3). It is worth highlighting that, although there has been an increase in access to sanitation services, the percentage of coverage of the Amazon is well below the national average (IBGE, 2010).

The access of households to sanitation through the general mains is still restricted in the region, with only 14% of the total number of households served. For solid waste collection, the coverage percentage was 71% of the served households. With the exception of the state of Maranhão, in all other

states of the Legal Amazon the percentage was above 70% (Table 3).

Advances in access indicators related to sanitation actions in the Amazon are expressive, especially regarding access to water supply services. However, when comparing these indicators with those of other regions, states and cities of the country and the quality of the services provided, it is observed that the region still maintains a persistent adverse situation. According to the last *Pesquisa Nacional de Saneamento Básico* (Basic Sanitation National Survey - PNSB) (2008), among the cities that distributed water without any type of treatment, the ones located in the North region (20.8% of the cities) were in evidence, where 7 states of the Legal Amazon are located. On that item, the states of Pará (40.0%) and Amazonas (38.7%) presented the most unfavorable percentages (IBGE, 2008).

The same states were those in which more than 40% of the cities pointed out instances of rationing supplies. The most frequent reasons cited by the cities for rationing were: problems related to drought/dry weather (50.5%); insufficient water at spring (39.7%); deficiency in production (34.5%); and insufficient distribution (29.2%) (IBGE, 2008).

Regarding the disposal of solid urban waste, the access to the appropriate destination in Legal Amazon was also restricted, for in more than 70% of the cities in the disposal of households and/or public solid waste was accomplished by means of open sewers (landfill) (IBGE, 2008).

### Health indicators

Freitas and Giatti (2009) pointed out that the health status of the states of the Amazon is very heterogeneous, with expressive number of deaths by infectious and parasitic diseases. For these diseases, the states of Acre, Amazonas, Roraima, Pará, and Maranhão reached the highest instances of the Country. However, it is possible to observe the significant occurrence of deaths by circulatory system diseases, values that match the ones achieved nationally. Another important issue is the advances in notifications of external causes (injuries by accidents and violence), first cause of the deaths observed in the states of Roraima and Amapá.

For infant mortality rate, a consistent decline since the 1970s was observed in the country, and the Legal Amazon related to the expansion of mother and child health programs, especially those aimed at pre-natal, childbirth, and puerperium; to the extension of medical services in quite lacking areas of the Country; to basic sanitation actions and the large changes in reproductive patterns that showed sharp declines in fertility levels (RIPSA, 2013).

Between the years of 1980 and 2010, for example, the infant mortality rate was 69.1 to 15.97 deaths for every 1,000 children born alive (RIPSA, 2013). In 2010, the states of the Legal Amazon reached rates between 18 (Roraima) and 25.41 deaths for every 1,000 children born alive (Amapá) (Table 4). The states of Amapá and Maranhão recorded adverse results in the country. Even with the positive developments over the decades, the state of Maranhão has maintained the lowest percentage drop in this indicator (50%) (RIPSA, 2013).

For diseases related to adverse conditions of sanitation, acute diarrheal disease (ADD) in children under five years old. In the period from 1998 to 2007, the rates of hospitalization per 1,000 inhabitants for ADD in children under 5 years old have shown that there is a tendency of decrease in these hospitalizations in the Legal Amazon (PAHO, 2010).

**Table 4 – Infant Mortality Coefficient, hospitalization rates for DRISA, ARI, and ADD in SUS in children younger than 5 years old. Brazil, Legal Amazon-2010**

Region/State	Infant Mortality Coefficient	Hospitalization rate for DRISA in SUS in children under 5 years old per 1,000 inhabitants	Hospitalization rate by ARI on SUS in children under 5 years old per 1,000 inhabitants	Rate of Hospitalization by Acute Diarrheal Diseases in children under 5 years old in SUS per 1,000 inhabitants
Brazil	15.97	21.99	46.21	8.89
Amazon	18.64	31.12	45.03	12.38
Rondônia	18.92	41.65	55.74	26.64
Acre	20.42	24.79	29.91	3.71
Amazonas	20.57	14.33	35.82	7.05
Roraima	18.00	28.44	42.93	16.19
Pará	21.46	54.92	60.65	21.6
Amapá	25.41	11.89	28.34	6.84
Tocantins	20.45	35.70	59.25	5.86
Maranhão	21.88	39.63	42.68	14.14
Mato Grosso	19.55	28.76	49.94	9.42

Source: RIPSA (2013).



However, according to data from 2010, the states of the Legal Amazon still have worrying indicators of such events, representing 30% of total hospital admissions in the country. The highest occurrences were found in the states of Amapá and Maranhão. It is worth pointing out that, for diseases related to inadequate sanitation (DRISA), the states of the Legal Amazon also reached the highest instances of the country. In 2010, the states of Pará, Rondônia and Maranhão reached the highest rates of hospitalization in SUS of children younger than 5 years old per 1,000 inhabitants of DRISA at the national level (Table 4), with the same positions observed from 1998 to 2009 (RIPSA, 2013).

At the intersection of social indicators (extreme poverty, illiteracy rate, and HDI) in the year of 2010, with the rates of hospitalization for ADD and DRISA, we observed that the state of Maranhão (which showed the worst performance in the HDI, illiteracy and extreme poverty rate indicators) obtained the third highest rate of hospitalization of the DRISA and the fourth highest rate for the ADD. The state of Pará, which had the second worst performance for the HDI, was fourth for illiteracy rate, achieved the second highest rate of hospitalization for ADD and the highest rate for DRISA (Tables 2 and 3).

As for hospitalizations due to acute respiratory infection (ARI) in children younger than 5 years old, from 1998 to 2010, the data of the Legal Amazon did not show many variations in relation to the national average, only highlighting Mato Grosso and Pará (PAHO, 2010). In 2010, the same profile observed over the years was observed in incidence rate by ARI in children younger than 5 years old in the states of the Amazon, which have achieved rates that ranged between 60.65 and 28.34 hospitalizations per 1,000 inhabitants (Table 4).

The diseases considered endemic in the Amazon region, such as malaria and American cutaneous leishmaniasis have direct relation with the anthropic processes that promote environmental change (such as deforestation, migration flows, construction of roads, agriculture, extensive cattle farming, and urban occupation on native forest areas), the seasonal variations, and the susceptibility of the population (Martins et al.,

2004). This direct relation explains the variability of the morbidity of diseases. For malaria, the states which have achieved the highest values for the Parasitic Annual Index (PAI) for the period from 1990 to 2010, were Acre, Roraima, Rondônia, Amazonas and Amapá (PAHO, 2010; Freitas; Giatti, 2009) (Table 5).

According to data from 2010, the incidence rate of American cutaneous leishmaniasis in the Amazon was of 70.26 cases confirmed for every 100,000 inhabitants. The states of Acre, Amapá, Mato Grosso, Roraima, and Rondonia recorded the greatest coefficients in the same year (Table 5).

Visceral leishmaniasis is expanding in Legal Amazon states. Until the late 1990s, the states of the Northeast region reached 90% of the cases in the country, but the states of Tocantins, Maranhão, and Pará are progressively showing significant rates over the years, which corroborates the spread of visceral leishmaniasis in the Amazon region (Silva et al., 2008). For example, in 2010, these states presented the highest incidence rates in the Legal Amazon (Table 5).

Among the diseases directly linked to living conditions and nutritional deficiencies, leprosy and tuberculosis are worth mentioning due to the indicators achieved in the region. According to the leprosy detection coefficient per 100,000 inhabitants for 2010, the states of Mato Grosso, Tocantins, Maranhão, and Rondônia presented the greatest results in the Country. The rates confirmed these states as hyper-endemic (Table 5). In studies in several cities of the Amazon, leprosy reached a hyper-endemic character, reaching, in the 21<sup>st</sup> century, prevalence rates in over 20 cases per 10,000 inhabitants. From 2001, cities of Maranhão have presented rates over 60 per 100,000 inhabitants - the highest municipal taxes in the Amazon (Aquino et al., 2003; Figueiredo; Moura da Silva, 2003).

In 2010, the highest incidence rates of tuberculosis per 100,000 inhabitants in the Legal Amazon states were in the Amazonas, Pará, Acre, Mato Grosso, and Maranhão (Table 5). At the national level, the states of Amazonas, and Pará presented, respectively, the second and fourth highest indicators (RIPSA, 2013).



**Table 5 – Incidence rate of Dengue fever, American cutaneous leishmaniasis, visceral leishmaniasis, and tuberculosis, leprosy coefficient, Annual Parasitic Index (API) in the Legal Amazon, Brazil (2010)**

Region/ State	Dengue incidence rate per 100,000 inhabi- tants	Incidence rate of American cutaneous leishmani- asis (ACL) per 100,000 inhabitants	Incidence rate of visceral leishmaniasis per 100,000 inhabitants	Tuberculosis incidence rate per 100,000 inhabitants	Coefficient of leprosy per 100,000 inhabitants	API (Annual Parasite Index): positive tests of malaria per 1,000 inhabitants
Brazil	514.09	11.59	1.8	37.57	18.75	1.71
Amazon	1057.37	70.26	4.56	29.04	49.26	19.81
Rondônia	1307.66	59.97	-	29.95	58.82	27.53
Acre	4741.68	141.64	-	41.99	34.22	49.44
Amazonas	277.76	32.46	-	66.73	20.58	21.25
Roraima	1638.26	140.07	3.55	28.86	32.63	42.34
Pará	194.99	31.78	4.05	47.57	49.43	18.02
Amapá	474.96	68.26	-	28.68	21.06	18.61
Tocantins	637.32	40.62	25.15	13.44	79.06	0.01
Maranhão	87.59	38.04	6.51	32.14	62.45	0.36
Mato Grosso	156.13	79.54	1.75	38.71	85.07	0.72

Source: RIPSA (2013).

## Discussion

The insertion of the Amazon in national economic development projects reoccurred in different moments of its history, as in the case of the exploitation of the “drugs of the *sertão*” (spices, fruit, seeds, roots, among other typical products of the region) and the “cycle of rubber” (1879/1912 and 1942/1945). Since the late 1970s to the present, mineral exploration, agribusiness, mining, prospecting, and large ventures (such as dams) can be mentioned as fronts for economic expansion in the region, in addition to the Free-Trade Zone and the Industrial Center of Manaus (Monteiro, 2005).

This development model promoted deep changes in the dynamics of the region and altered the old secular pattern of occupation, based on low demographic density, subsistence gathering and the river flow (Castro, 2012; Becker, 2009; Sathler et al., 2009).

Confalonieri (2005) and Netto et al. (2010) warned that the development process undertaken in the Amazon region generated environmental transformations with risks to human health. In

this regard, we can mention: the pollution of water bodies by mercury from the gold fields; microbial contamination by sanitation deficiencies in the cities; respiratory diseases caused by the smoke of burning after deforestation; the local changes of hydrological cycles that provide potential breeding grounds for mosquitoes, etc.

According to Rojas and Toledo (1998), the historicity of the diseases considered endemic in the Amazon region, such as malaria, leprosy and tuberculosis, maintains a close relationship with demographic, ecological, socioeconomic and cultural changes in the region, which determines a continuous reorganization of its geographical space, and changes the processes of reproduction of these endemics.

In turn, the dynamics of occupation and exploitation of the region promoted changes in the dynamics of natural ecosystems, anthropization of the landscape, and urbanization, allowing the invasion of natural habitats of these animals, in addition to greater risks of occurrence and reoccurrence of infectious process (Paraná et al, 2008; Vasconcelos,

2006; Confalonieri, 2005).

Given this complex scenario and from the various indicators analyzed, it is possible to produce some thoughts on what might be called a socio-environmental and sanitary scenario in the Amazon region, identifying its vulnerabilities. In general, following a national trend, all the states of the Amazon have undergone increments and advances in economic, social, and quality of life indicators in the last two decades.

It is worth pointing out that, in spite of the increments achieved in economic indicators, that reach did not provide the states with a performance compatible with social indicators in comparison to the other states of the country. In the meantime, the state of Maranhão in the Northeast region presented the most adverse social indicators of the country, reaching the worst poverty index, the second worst HDI, and the fourth highest rate of illiteracy.

As for the environmental indicators, there is a clear tendency of the states that make up the “arc of fire” to have presented the most unfavorable indexes, resulting from the advances of deforestation, the agribusiness (mainly soybeans), extensive cattle farming, and burnings that accompany such economic fronts (Waichman, 2008). The highest rates of deforestation and hotspots in the country were recorded in states like Mato Grosso, Pará, and Maranhão.

This situation is of great concern, by the prospect that the economic development in the region, which promoted fast and profound changes in the dynamics of ecosystems (mainly by deforestation), be characterized as unsustainable by enabling elevation of social indicators during the rise of the occupation and, later, fall of the results at the end of the process of deforestation in the Amazon locations (Rodrigues et al, 2009).

According to the crossings of indicators, developments in economic indicators (GDP and GDP per capita) were not observed in environmental indicators (rate of deforestation and use of pesticides). The state of Mato Grosso, for example, obtained the second largest GDP in the Amazon and the most unfavorable results in deforestation and use of pesticides, in addition to the lower development in the

HDI. The state of Pará, which reached the highest GDP, presented 22.89% situation of extreme poverty and the high rate of deforestation (Tables 1, 2 and 3).

Thus, despite the considerable increase of wealth produced in the Amazon region in recent decades, such performance will not be observed in sanitation indicators for the region under the same dynamics. It is a public policy that is essential to the health of populations that, nonetheless, still have limited access to sanitation actions. According to the data reviewed herein, the states of the Amazon had the the most unfavorable water supply access indicators in the country, even with its water potential.

Such uneven distribution of sanitation services at the national level may be due to the profound social inequalities that still exist in the Country, supported by data from access to basic sanitation services of the 2010 Census and the 2008 PNSB. According to the data, these services were available to 77.50% users who had household income up to two minimum wages. The households had total income of up to half the minimum wage were served by only 41.3% of the sanitation services (IBGE, 2010).

Thus, the states of the Amazon have reached the most unfavorable results in social and health indicators at the national level, expressing the population marginalization in some way. This inequality of access to sanitation services is also observed when comparing the cities in the region with the rest of the Country. It should be noted that the adverse data regarding accessibility to inadequate sanitation services is compatible with the adverse indicators of prevalence and incidence of inadequate sanitation-related diseases and acute diarrheal diseases.

By crossing the data, it even indicated antagonistic performance situations between economic and social indicators and the rates of hospitalization. The state of Pará, for example, which showed the highest GDP of the Legal Amazon, had unfavorable results in the HDI, poverty, and illiteracy rates indicators of hospitalization for acute diarrheal and sanitation related diseases. Now, the state of Maranhão presented a development in the economic indicators, but could not overcome the adverse data of extreme poverty, HDI and education (illiteracy rate), that were compatible with the hospitalization

rates for DRISA and ADD (Tables 1, 2, and 4).

The infant mortality rate for the Amazonian states followed the trend of increasing reduction observed at the national level, however still remains among the largest ones in the country. Regarding that issue, Szwarcwald et al. (2002) found that 35% of the population of the northern region has the largest occurrences of under-registration of deaths. According to the authors, such events are related to the burials in clandestine cemeteries without the requirement of the death certificate, associated with poverty in the rural area.

Concerning leprosy and tuberculosis, illnesses directly related to precarious conditions of life of the population, the indicators presented corroborate existing research on these diseases in the region (Campos et al., 2014). Thus, the areas considered endemic for leprosy comprise from the state of Rondônia, North and Central Mato Grosso, South Pará, Northwest Tocantins to the far West of the state of Maranhão. This area corresponds to the “arc of fire” of the Legal Amazon. The state of Maranhão stands out by presenting rates considerably higher than the other states (Silva et al., 2010).

The Amazonian states also showed high rates of incidence of tuberculosis, which can be attributed to the long history of endemicity in the region and the persistence of poverty, precarious access to sanitation actions and negative indicators of quality of life in general. Surveys carried out among indigenous peoples of the Amazon showed that the incidence rates of TB in these populations can be up to ten times greater than in the Brazilian population in general, with significantly high risk of illness and death (Levino; Oliveira, 2008).

Such findings provide subsidies to understand the dynamics of the disease in the Amazon region. It should be noted that, historically, the rates of incidence and prevalence of tuberculosis at municipal level are higher in the Legal Amazon. Since 2003, this condition led the Northern region to be considered as a priority in the National Tuberculosis Control Program due to persistent incidence and prevalence rates achieved over the decades, that can be attributed, among other determinants, to the precariousness of living conditions, the shortcomings

of the organization and the lack of accessibility of the population to the Unified Health System (SUS) (Levino; Oliveira, 2008).

Other aspects of the health of the Amazonian populations were indicated by Alencar et al. (2007), who warn about the exclusion of the rural Northern region from the national epidemiological scenario, with a vast emptiness of scientific information on the health, nutrition and survival conditions in nationwide surveys carried out by official government bodies. Observing such information gaps, the authors based their analysis on the evolutionary analysis of the surveys conducted in the state of Amazonas in recent decades, suggesting the persistence of a food insecurity situation evidenced by the high prevalence of children malnutrition, iron deficiency anemia, and hypovitaminosis A, compounded by the high frequency of gastrointestinal parasitic infections.

Thus, it is worth mentioning that, in this complex health framework, 98% of the cases of malaria and 35% of the cases of leprosy in the Country occur in the Amazon population, with areas considered hyper-endemic for fulminant viral hepatitis. In the mid-1990s, diseases such as cholera and dengue fever have resurfaced in the Amazon. However, the chronic degenerative diseases presented a very similar profile to the rest of the country (Confalonieri, 2005; Freitas; Giatti, 2009).

It is from this reflection that we seek to understand the indicators and studies here singled out as revealing the vulnerability of the population that makes up the Brazilian Amazon, facing a development model designed for the region that produced social inequalities and negative effects on its health and environmental framework.

## Conclusion

The development model implemented in the Amazon promoted deep changes in the dynamics of the region and altered the old secular pattern of occupation (Becker, 2005; Sathler et al., 2009). If, on the one hand, we can consider that some of the economic and social indicators have improved, on the other, huge inequalities persist as well as negative effects on the health and environmental framework,

making certain sections of the population more vulnerable (the poorest people) as well as certain areas (the agricultural expansion, logging and mineral extraction, in addition to the areas of urbanization and industrialization).

Rodrigues et al. (2009), when comparing the HDI with the deforestation indicators from 286 cities of the Brazilian Amazon, they noted that in the initial stage of the economic expansion fronts (extensive agriculture, livestock and mineral exploitation, among others), there is a relative increase in the HDI and increased deforestation. After this stage, the HDI started a process of decline and its evolution remained at lower levels, the stage at which the expansion fronts have settled in the cities. This research points to the unsustainability of this development model, which produces social gains that decline when the natural resources are exhausted.

In relation to the population health aspects, whereas the analysis and discussion held in this article, the results revealed that the main social and environmental changes that have been taking place in the Amazon region contribute to the emergence of a very complex health framework, overlapping the risks of illnesses and diseases. This chart shows the expressiveness of infectious and parasitic diseases, with the emergence and re-emergence of some diseases caused by profound changes in vectors and cycles of etiological agents (Freitas; Giatti, 2009).

Thus, such health situation is combined with: precarious conditions of sanitation; respiratory diseases caused by burnings; chronic degenerative diseases caused by both chemical contamination resulting from the intensive use of pesticides and mercury, as well as by changes in living standards; traffic accidents resulting from a precarious process of urbanization; violence in the cities and in the countryside in a structurally unequal Amazon characterized by conflict situations.

Thus, the important current debate on the Amazon Rain Forest, models of economic development and their environmental costs cannot be disassociated from the discussions and analyses of the living conditions of the population of the region, which are increasingly urbanized and living daily with the overlapping of environmental and health risks.

This article built a broad mosaic of indicators on development, environment and health in a large and diverse region of the country, which is a challenge in this type of study. However, one can't help but point out the existing limits in this paper when considering the breadth and diversity of the Amazon which require considering different patterns of geographical and health-related situations, resulting in different modes of use and occupation of space and their stories. In this process of tensions, mediations and combinations between the general and the particular items, it is worth remembering important efforts towards that, in the form of books, such as those organized by Rojas and Toledo (1998), as well as the latest one organized by Oliveira (2014), or even in the form of articles, like Viana et al. (2007). With this article, we hope to contribute to the debate on these tensions and mediations, without losing sight of the more general debate on the model of development and its impacts on the environment and health in the Amazon.

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#### Authors' contribution

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