RBGDR

SOCIAL EFFICIENCY IN THE LEGAL AMAZON: AN ANALYSIS USING DATA ENVELOPMENT ANALYSIS (DEA)

EFICIÊNCIA SOCIAL NA AMAZÔNIA LEGAL: UMA ANÁLISE POR MEIO DO DATA ENVELOPMENT ANALYSIS (DEA)

RBGDR

REVISTA BRASILEIRA DE GESTÃO E DESENVOLVIMENTO REGIONAL
V.21, N°2, Mai-Ago/2025 | Taubaté/SP - Brasil | ISSN 1809-239x

SOCIAL EFFICIENCY IN THE LEGAL AMAZON: AN ANALYSIS USING DATA ENVELOPMENT ANALYSIS (DEA)

EFICIÊNCIA SOCIAL NA AMAZÔNIA LEGAL: UMA ANÁLISE POR MEIO DO DATA ENVELOPMENT ANALYSIS (DEA)

Diogo Ferraz[1] | Gregory Moraes[2]

Maria Angélica de Almeida Corrêa[3] | Francisca Diana Ferreira Viana[4]

Received: 08/22/2024
Accepted: 05/13/2025

[1] PhD in Production Engineering (USP).
Professor at the University of São Paulo.
Lorena - SP, Brazil.
E-mail: diogoferraz@alumni.usp.br

[2] PhD candidate in Production Engineering (UNESP).
Bauru - SP - Brazil.
E-mail: gregory.moraes@unesp.br

[3] PhD in Fisheries Sciences in the Tropics (UFAM).
Professor at the Federal University of Amazonas.
Manaus - AM, Brazil,
E-mail: angelicacorrea2011@gmail.com

[4] PhD in Economics (UFMG).
Professor at the Federal University of Ouro Preto.
Ouro Preto - MG - Brazil.
E-mail: fviana@ufop.edu.br

ABSTRACT

Numerous studies have examined human development in emerging economies. However, there is a notable scarcity of research focused specifically on human development in the Brazilian Amazon region. Furthermore, existing studies often overlook the financial responsibility involved in converting wealth and public resources into tangible improvements in human development for the local population. In light of this gap, the present study aims to assess the social efficiency of the Amazon region, thereby revealing the social performance of its microregions while considering their strengths and potential for local development. To achieve this objective, the study analyzed five dimensions represented by 14 social variables, in addition to Gross Domestic Product (GDP) and public expenditures in the areas of education and culture, housing, and health and sanitation. Using Data Envelopment Analysis (DEA), the research examined 87 microregions across the nine states that comprise Brazil's Legal Amazon. The results indicate a weak correlation (19.07%) between the Social Efficiency Index (SEI) and the Human Development Index (HDI) in the region, suggesting that higher levels of human development do not necessarily translate into greater social efficiency. Moreover, 63.22% of Amazonian microregions are situated in the lowest quartile of the social efficiency ranking. The most efficient microregion identified was Alto Paraguai (Mato Grosso). In contrast, microregions with high HDI but low SEI are also located in Mato Grosso, a state largely characterized by agricultural and livestock activities. The least efficient microregions are primarily concentrated in the state of Pará, many of which are marked by extractive economic activities, particularly mining. The SEI provides an objective tool for policymakers, enabling more effective allocation of public resources aimed at fostering equitable and sustainable local development.

Keywords: Human development. Social efficiency. Data Envelopment Analysis (DEA). Amazon Region

RESUMO

Diversos estudos analisam o desenvolvimento humano em economias emergentes. Entretanto, há escassez de estudos analisando o desenvolvimento humano na Região Amazônica brasileira. Ademais, os estudos negligenciam a responsabilidade financeira em converter riqueza e recursos públicos em desenvolvimento humano para a população local. Por este motivo, este artigo tem como objetivo mensurar a eficiência social da Região Amazônica, o que permite revelar a performance social das microrregiões, levando em consideração os pontos fortes para o desenvolvimento local. Para tanto, este artigo analisou 5 dimensões representadas por 14 variáveis sociais, além do Produto Interno Bruto (PIB) e dos gastos sociais em educação e cultura, habitação e moradia, e saúde e saneamento. Por meio do *Data Envelopment Analysis* (DEA), foram analisadas 87 microrregiões de 9 estados da Amazônia Legal brasileira. Os resultados revelaram que há baixa correlação (19,07%) entre o Índice de Eficiência Social (IES) e o Índice de Desenvolvimento Humano (IDH) na Amazônia. Além disso, 63,22% das microrregiões amazônicas estão localizadas no pior quartil do ranking de eficiência social. A região mais eficiente foi Alto Paraguai (MT). As regiões com maior IDH e pior IES estão localizadas no Mato Grosso, área caracterizada pela Agropecuária. As regiões menos eficientes estão concentradas no Pará, sendo que algumas têm como característica o extrativismo, em especial, o setor da mineração. Por meio do IES, os formuladores de políticas públicas possuem uma ferramenta objetiva para distribuir recursos públicos para o desenvolvimento local.

Palavras-chave: Desenvolvimento humano. Eficiência Social. Análise envoltória de dados (DEA). Região Amazônica.

INTRODUCTION

The Amazon Region is rich in natural resources, containing more than half of the planet's biodiversity (IPAM, 2024). Despite this abundance, the region faces the challenge of overcoming poverty, reducing social inequality, and improving the population's quality of life (Ferraz et al., 2021a). In this context, social and economic situation of the region highlights the challenges of regional development in the absence of viable alternatives to promote economic and socio-environmental development (Romano & Mascarenhas, 2018). For instance, the Household Budget Survey (POF/IBGE, 2017–2018) indicates that all states in the Amazon Region—except for Mato Grosso—rank among the lowest in Brazil's Quality of Life Loss Index (IPQV) (IBGE, 2020).

For this reason, several studies have assessed quality of life and human development in the Amazon Region (Silveira, Silva & Carvalho, 2008; Ferraz et al., 2021b; IBGE, 2020). For instance, Silveira et al. (2008) applied fourteen quality of life indicators to Brazil's Northern region, revealing that the city of Belém (PA) had the highest quality of life among the regions analyzed. Conversely, the municipality of Ipixuna (AM) showed the lowest quality of life index in the region (Silveira, Silva

& Carvalho, 2008). However, these studies employ quality of life indicators without considering social deprivation and the limitations of public resources available for promoting human development.

The concept of human development, based on Amartya Sen's Capability Approach, understands freedom as both the means and the end of economic development. According to Sen (2000), human development is a process of expanding the freedoms enjoyed by individuals. Thus, the freedom generated is itself a development component (Sen, 2000). Public policymakers should therefore focus on enhancing human capabilities and individual freedom rather than merely increasing the volume of goods or economic growth (i.e., Gross Domestic Product – GDP). The development-as-freedom approach enables a deeper understanding of various social phenomena such as poverty, inequality, and quality of life (Nussbaum, 2000; Sen, 1988).

International literature has proposed various absolute indicators for measuring human development, such as the Human Development Index (HDI) and the Multidimensional Poverty Index (MPI) (UNDP, 2016; Alkire & Foster, 2011). However, these absolute indicators of human development (i.e., HDI) and deprivation (i.e., MPI) do not assess whether public policymakers are making efficient use of financial resources to achieve better human development outcomes (Despotis, 2005). The human development and capabilities approach has shown that growth and income are not the only means to achieve development (Ferraz et al., 2020). In this regard, human deprivations—such as hunger or inadequate health and education—are often linked to distribution issues and institutional failure rather than to productive capacity constraints (Dreze & Sen, 1990).

It is worth noting that improvements in human development contribute to economic development. This is because increases in human capital generate positive externalities for the economy (Ranis, Stewart & Samman, 2006). Public policymakers should therefore focus on reducing human deprivations and improving social efficiency. In turn, social efficiency refers to the ability to convert available financial resources into higher quality of life for the population (Ferraz et al., 2020).

Given the above, this article aims to identify which regions in the Legal Amazon use public resources (social expenditures and GDP) in a socially efficient manner to generate social benefits for the local population. The objective of this study is to measure the social efficiency of the Amazon Region using Data Envelopment Analysis (DEA), a method that allows the assessment of the social performance of

micro-regions and takes into account local development strengths. This study offers several contributions to the specialized literature. First, it proposes an indicator for evaluating regional human development in the Amazon Region (Ferraz et al., 2021a; Rodrigues & Silva, 2023). Second, the analysis of micro-regions informs decision-making related to the allocation of public resources, with the goal of enhancing local human development. The proposed indicators and regional analysis are relevant tools for public policymakers, as this article reveals which regions demonstrate greater capacity to generate human development from the financial resources available. Finally, this type of analysis is relevant not only for state and federal policymakers but also for funding agencies and international organizations seeking to invest in the development of the Amazon.

In addition to this introduction, Section 2 discusses the concept of Social Efficiency and the characteristics and challenges of the Amazon Region. Section 3 presents the DEA methodology. Section 4 discusses the results. Lastly, Section 5 addresses directions for future research, limitations, and the conclusions of this study.

HUMAN DEVELOPMENT AND SOCIAL EFFICIENCY

According to the United Nations, human development is a process of expanding freedoms for all human beings. Achieving quality of life should be the main goal of countries' socioeconomic development (Sen, 1988). In this sense, the Human Development Index (HDI) reflects a geometric mean of income, life expectancy, and education (UNDP, 2016). However, Sagar and Najam (1998) argue that the HDI offers a distorted and limited view of human development. Other criticisms include the need for qualitative measures of education, consideration of gender and income inequality, and aspects such as security, democracy, the environment, refugee conditions, and discrimination (Bilbao-Ubillos, 2013; Herrero; Martínez; Villar, 2010; Dominguez-Serrano; Blancas, 2011).

Given these limitations, Fukuda-Parr et al. (2009) proposed a new indicator that considers six fundamental rights in its composition: health, housing, education, food, social security, and decent employment. Dominguez-Serrano and Blancas (2011) emphasized the importance of measuring the gender perspective in human development indicators. Ravallion (2012) reformulated the HDI as a cumulative function for income, health, and education. Grimm et al. (2008) developed a new method

that incorporates the effects of income distribution on human development.

Another important indicator is the Multidimensional Poverty Index, which evaluates income. This indicator analyzes how people experience poverty in multiple and simultaneous ways (Alkire; Foster, 2011). With the continued evolution of the definition of poverty, current definitions are broader than monetary poverty alone (Ribeiro; Silva; Guimarães, 2015). According to Ribeiro et al. (2015), it is easier to measure poverty using a direct definition, such as establishing a poverty line below 40% of a country's average income, as done by the OECD (2008). However, poverty is not only reflected by lack of income, as it does not encompass the different dimensions of this social phenomenon (Atkinson, 2003).

In this regard, the economic literature understands deprivation as unmet needs in various aspects of social and economic life (Townsend, 1987). Townsend (1987) points out that social and material deprivation results from the individual accumulation of multiple deprivations. Accordingly, Ribeiro et al. (2015) analyzed the mechanisms of macroeconomic income transfers and their influence on social deprivation indicators for European Union countries. However, these indicators still neglect the financial constraints that regions face in promoting human development. It is noteworthy that financial constraints are a reality for developing countries, especially in the Amazon Region.

The concept of social efficiency reflects the ability of a country or region to transform produced wealth into human development or quality of life (Mariano; Sobreiro; Rebelatto, 2015). In other words, social efficiency seeks to understand how a region converts available financial resources, such as social spending and Gross Domestic Product (GDP), into human development (Mariano, 2019). Social efficiency is a recent approach that uses a Data Envelopment Analysis (DEA) model, employing GDP per capita as input and education and life expectancy as outputs. For example, Despotis (2005) found that Spain, Greece, New Zealand, Japan, Sweden, Canada, and the United Kingdom are socially efficient countries. Mariano and Rebelatto (2014) advanced this by applying a DEA model with weight restrictions and tie-breaking methods. The results show that the most efficient countries in converting wealth into quality of life were those that were part of the former Soviet Union or had a socialist past. Ferraz et al. (2018) contributed to this theory by measuring the capacity of countries to use a complex productive structure to improve quality of life. Ferraz et al.

(2018) used a Window Analysis for Asian and Latin American countries between 2010 and 2014. The results indicate that all countries were efficient in 2014, except for China and the Philippines. Over time, only South Korea, Singapore, and Japan remained efficient. Moreover, in 2014, Cuba was the country that most frequently served as a benchmark for inefficient countries.

Several studies have analyzed social efficiency at the regional level. Morais and Camanho (2011) advanced the field by measuring the social efficiency of 284 European cities, proposing 29 quality-of-life indicators as outputs and GDP per capita as input. The study showed that the Social Efficiency Index diverges from the Human Development Index, highlighting that wealthier countries or those with higher quality of life are not always the most socially efficient. Ferraz et al. (2020) proposed new indicators to analyze the human development and social efficiency of 129 Brazilian mesoregions. The results show that although absolute indicators demonstrate lower human development in the Northern and Northeastern regions, social efficiency indicates that some areas in these regions can be more efficient than traditionally wealthy regions like the South and Southeast. However, there is still a lack of studies specifically analyzing the Amazon Region. This article fills that gap in the literature on social efficiency and human development.

METHODS

This article employs the Data Envelopment Analysis (DEA) method to calculate social efficiency and social deprivation in the Brazilian Amazon Region. DEA is ideal for this type of analysis because it aggregates relevant information in a simple and direct way for public policymakers (Ferraz et al., 2020). Developed by Charnes et al. (1978), DEA is a mathematical method based on linear programming that measures the performance of Decision Making Units (DMUs) through a piecewise linear frontier. DEA reveals the maximum number of outputs that can be produced per unit of input, reflecting the production limit determined by the constraints of a region (Mariano & Rebelatto, 2014; Cook & Zhu, 2014). According to Cook and Zhu (2014), each region can be ranked by performance, ranging from zero (worst performance) to one (best performance). To reach the top of the ranking, DEA maximizes weights by focusing on the strengths of each region (Mariano, Sobreiro & Rebelatto, 2015).

DEA models mainly differ by their assumptions about returns to scale and orientation. The Constant Return to Scale (CRS) model assumes that outputs vary proportionally to inputs (Charnes et al., 1978). In contrast, the Variable Return to Scale (VRS) model identifies variations between inputs and outputs and defines three frontier areas: (a) increasing, where outputs grow proportionally more than inputs; (b) constant, where there is proportionality between inputs and outputs; and (c) decreasing, where outputs grow proportionally less than inputs (Banker et al., 1984). For the problem proposed in this article, the advantage of the VRS model lies in its ability to make relative comparisons between regions (i.e., microregions) with different sizes and financial conditions. Table 1 summarizes the DEA models.

Table 1 | Main radial DEA models in multiplier form

Model	Input-oriented	Output-oriented
CRS	$MAX \sum_{i=1}^{m} u_i . y_{i0}$ Subject to: $\sum_{j=1}^{n} v_j . x_{j0} = 1$ $\sum_{i=1}^{m} u_i . y_{ik} - \sum_{j=1}^{n} v_j . x_{jk} \leq 0 \; for \; k = 1,2,\dots,h$	$MIN \sum_{i=1}^{n} v_j . x_{j0}$ Subject to: $\sum_{j=1}^{m} u_i . y_{i0} = 1$ $\sum_{i=1}^{m} u_i . y_{ik} - \sum_{j=1}^{n} v_j . x_{jk} \leq 0 \; for \; k = 1,2,\dots,h$
VRS	$MAX \sum_{i=1}^{m} u_i . y_{i0} + w$ Subject to: $\sum_{j=1}^{n} v_j . x_{j0} = 1$ $\sum_{i=1}^{m} u_i . y_{ik} - \sum_{j=1}^{n} v_j . x_{jk} + w \leq 0 \; for \; k = 1,2,\dots,h$ *w no restrictions signal*	$MIN \sum_{i=1}^{n} v_j . x_{j0} - w$ Subject to: $\sum_{j=1}^{m} u_i . y_{i0} = 1$ $\sum_{i=1}^{m} u_i . y_{ik} - \sum_{j=1}^{n} v_j . x_{jk} + w \leq 0 \; for \; k = 1,2,\dots,h$ *w no restrictions signal*

Source: Mariano and Rebelatto (2014, p. 5)

Where: x_{jk} represents the amount of wealth j of a region k; y_{ik} represents the amount of social dimensions i of a region k; x_{j0} represents the amount of wealth j of the region; y_{i0} represents the amount of social variables i of the region; v_j represents the weight of GDP and public expenditures j for the region; u_i represents the weight of social dimension i for the region; $\grave{e}$ means the efficiency of the Brazilian region to be analyzed; $\ddot{e}_k$ is the contribution of region k to the

region's target; m represents the number of social dimensions analyzed; n represents the number of GDP and public expenditures analyzed; and w represents the scale factor.

Five dimensions represented by 14 social variables were analyzed to evaluate human development and social efficiency in the Brazilian Amazon. The data were collected from the latest Brazilian Census (IBGE, 2019). The choice of the Amazon Region is justified due to its worldwide relevance for environmental issues and the social problems faced by the region. Moreover, there is data availability from a reliable and comparable database. Table 2 summarizes the analyzed variables and presents previous studies.

Table 2 | Analyzed Variables

	Variables	Dimension	Theoretical Framework
Inputs	Population	General	Morais and Camanho (2011)
	Gross Domestic Product (GDP)	Wealth	Despotis (2005)
	Public Expenditure on Education and Culture	Education	Varela (2010); Andrett et al. (2017)
	Public Expenditure on Housing	Housing	Varela (2010); Andrett et al. (2017)
	Public Expenditure on Health and Sanitation	Health	Varela (2010); Andrett et al. (2017)
Outputs	Literate People	Education	Despotis (2005); Raab et al (2000)
	Children in Daycare	Education	Morais and Camanho (2011)
	Owned Residences	Housing	Morais and Camanho (2011)
	Homes with Electricity	Housing	Morais and Camanho (2011)
	Homes with Piped Water	Housing	Morais and Camanho (2011)
	Homes with Garbage Collection	Housing	Morais and Camanho (2011)
	Infant Mortality	Health	Ramanathan (2006)
	Number of Vaccinated People	Health	Morais and Camanho (2011)
	Life Expectancy	Health	Despotis (2005)
	Formal Employees	Economic	Morais and Camanho (2011)
	Gini Index	Economic	Malul et al (2009)
	Extremely Poor People	Economic	Morais and Camanho (2011)
	Number of Homicides	Institution	Mariano and Rebelatto (2014)
	Voter Participation	Institution	Morais and Camanho (2011)

Source: Prepared by the authors based on Ferraz et al. (2020).

The inputs (i.e., wealth and social expenditures) must be correlated with the dimensions of social efficiency (i.e., education, housing, health, economy, institution). Note that previous literature indicates a correlation between wealth and public spending with the chosen social variables (Ferraz et al., 2020; Mariano, 2019; Mariano & Rebelatto, 2014). This stems from the need for financial resources (GDP and social spending) to promote social programs or public policies that drive the human development process. For example, housing expenditures in the Minha Casa Minha Vida Program are essential for improving indicators of household infrastructure in Brazil (i.e., home ownership) (Ferraz et al., 2020). Another example is the need for GDP in microregions for the construction of facilities in the health sector (i.e., hospitals) and education (i.e., schools, daycare centers). These public facilities improve the social indicators analyzed in the model (i.e., number of children in daycare, number of vaccinated people, etc.).

The 772 municipalities analyzed in the Brazilian Legal Amazon were divided into 87 microregions. According to IBGE (2017), a microregion is an area within a federative unit defined by the following dimensions: social process, natural environment, and communication network. These three dimensions allow this delimited space, called a microregion, to have a regional identity. This identity is a reality constructed over time by the local society. The analysis of microregions is crucial to highlight regional diversity, considering the economic, social, and cultural structure of each unit. Thus, this study examines the microregions with the objective of identifying regional units with greater social efficiency. Ferraz et al. (2020) argue that the analysis of municipalities is not appropriate because small municipalities lack autonomy in strategic areas such as health. These municipalities usually depend on medium-sized cities (seats) that serve the surrounding population in various aspects of human development.

The indicators calculated in this work primarily reference the study published by Ferraz et al. (2020). First, a primary absolute indicator called the Social Deprivation Index (SDI) was measured, which used the inverted frontier of the DEA-CRS model. This indicator reveals which regions present the worst social deprivations. Second, using a DEA-VRS model, two primary relative indexes were measured. The Social Efficiency with Standard Frontier (SESF) reveals which regions are more efficient in converting wealth into human development. The Social Efficiency Indicator with Inverted Frontier (SEIF) shows which regions perform worse in generating human development through financial resources. Table 3 summarizes the primary indicators.

Table 3 | Primary Indicators

Index	Objective	Method	*Input*
IPS Social Deprivation Index (SDI)	To assess the regions with the highest levels of deprivation (for this purpose, the greatest weights were assigned to the variables in which the region performed worse relative to the other units).	DEA-CRS with Inverted Frontier	Population
Social Efficiency with Standard Frontier	To evaluate social efficiency by giving greater weight to the variables where the region stands out the most compared to others (based on its strengths).	DEA-VRS with the standard frontier	GDP and Social Spending
Social Efficiency Indicator with Inverted Frontier	To assess social efficiency by giving greater weight to the variables in which the region stands out the most compared to others (based on its weaknesses).	DEA-VRS with Inverted Frontier	GDP and Social Spending

Source: Ferraz *et al.* (2020).

Note that two primary indicators were calculated using the Inverted Frontier technique. Angulo-Meza and Lins (2002) consider the strengths and weaknesses of each decision-making unit by combining the standard frontier and the inverted frontier. Thus, the combination of the primary indicators enables the creation of a composite indicator.

Thirdly, the Social Efficiency Indicator (SEI) was created, which combines the standard and inverted frontiers of the primary indicators. Furthermore, this indicator considers the relative efficiency of each region. The SEI also evaluates social efficiency according to the strengths and weaknesses of each region. Table 4 summarizes the composite indicators.

Table 4 | Composite Indicators

Indicator	Objective	Formula	Weight used	Scala
Social Efficiency Indicator (SEI)	To assess the performance of regions in converting social spending and/or economic wealth into capabilities, highlighting strengths and weaknesses.	SEI = β * + IEFP (1- β) * (1 - IEFI)	β = 0,5	(lowest efficiency) and 1 (highest efficiency)

Source: Ferraz et al. (2020).

Finally, all the indicators followed the Min-Max normalization method (Expression 2), making them comparable (ranging from zero to one).

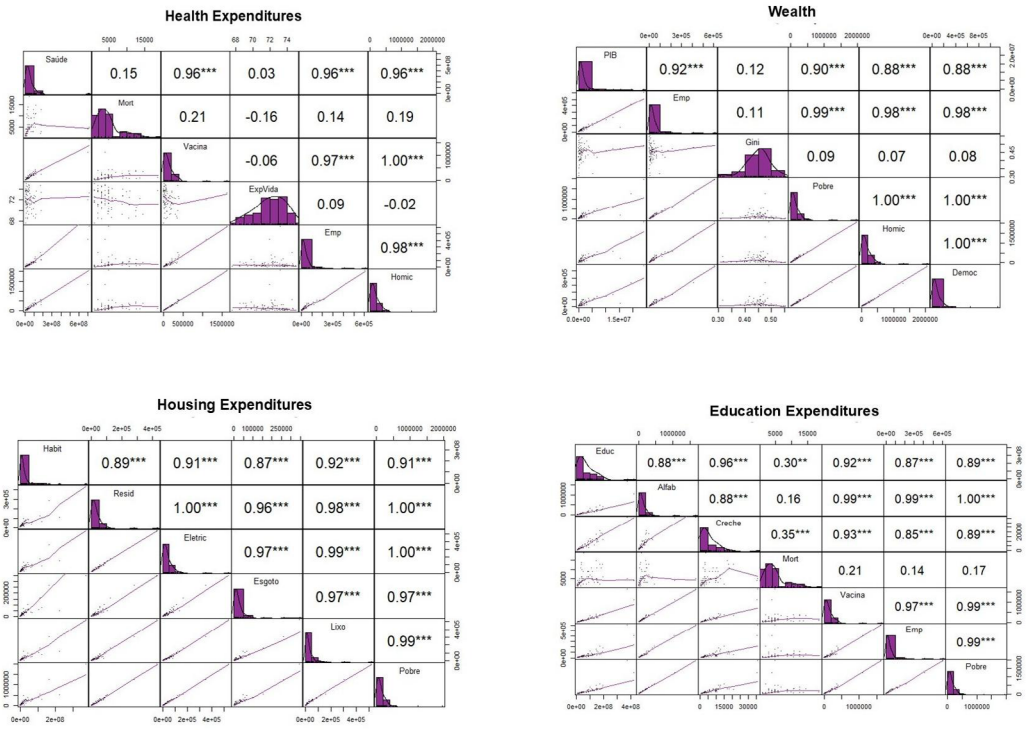
$$Normalized\ value\ x = \frac{x - Min(x)}{Max(x) - Min\ (x)} \qquad (1)$$

Where *Min(x)* and *Max(x)* are the minimum and maximum values of the sample, respectively. Additionally, the estimates were calculated using the software Stata and R. Thus, the Social Efficiency Indicator (SEI) indicates that microregions with a coefficient equal to zero are inefficient regions. On the other hand, microregions with a coefficient equal to one are considered efficient. This indicator provides a direct and useful interpretation for policymakers in the Brazilian Amazon region.

RESULTS AND DISCUSSION

This section discusses the results found for social efficiency in the Amazon region. The study analyzed 87 microregions across nine Brazilian states, corresponding to 772 municipalities in the country. First, the selected inputs and outputs for the DEA model were analyzed. The correlation analysis reveals that all inputs are correlated with the outputs. For example, wealth (GDP) correlates with the number of employed people (92%), the Gini Index (12%), people in extreme poverty (90%), the number of homicides (88%), and democratic participation (88%). Education expenditures correlate with the number of literate people (88%), the number of children in daycare (96%), infant mortality (30%), the number of vaccinated people (92%), employed people (87%), and people in extreme poverty (89%). Housing expenditures correlate with the number of people owning homes (89%), homes with access to electricity (91%), sewage (87%), garbage collection (92%), and people in extreme poverty (91%). Finally, health expenditures correlate with infant mortality (15%), vaccinated people (96%), life expectancy (3%), employed people (96%), and homicide rate (96%). Most of the correlations are statistically significant at the 1% level. This result corroborates the study by Ferraz et al. (2020). Note that undesirable outputs were adjusted by decreasing linear translation (Hashimoto & Ishikawa, 1993; Cook & Zhu, 2014), which explains the positive correlation among all variables. Figure 1 illustrates the relationship between the inputs and outputs of the DEA model.

Figure 1 | Relationship between Inputs and Outputs of the DEA Model



Source: Prepared by the authors.

Table 1 shows the average social efficiency and the traditional HDI (IBGE, 2010) for the states in the Amazon region. The Social Efficiency Indicator (SEI) shows that, on average, Acre (0.5741) is socially more efficient than the other states. On the other hand, Roraima (0.0906) was the state with the worst average position among the analyzed federative units.

Table 1 | Average Ranking of the Federal Units in the Amazon Region

Federative Units (FU)	Average of Normalized Indices	
	IES	HDI
Acre	0.5741	0.5068
Tocantins	0.5207	0.6606
Mato Grosso	0.3218	0.8118
Amapá	0.2916	0.6215
Pará	0.2542	0.5007
Rondônia	0.2097	0.6796
Maranhão	0.1729	0.5346
Amazonas	0.1041	0.3283
Roraima	0.0906	0.6594

Source: Prepared by the authors.

An important finding was the discrepancy between the Social Efficiency Indicator and the traditional HDI. Note, for example, that Roraima has the worst efficiency indicator but is among the states with the highest HDI (0.6594) in the region. This discrepancy between these types of indicators has been observed in other studies (Despotis, 2005a; 2005b; Ferraz et al., 2020). This result demonstrates that the absolute indicator (HDI) does not adequately reveal how financial resources are used to generate human development.

The analysis of the 87 Amazonian microregions showed that the Top-5 regions are as follows: Alto Paraguai (MT), Arari (PA), Brasiléia (AC), Araguaína (TO), and Rio Branco (AC). Note that no microregion from the states of Amapá, Amazonas, Rondônia, Roraima, and Maranhão appear in the Top-5 of social efficiency. This result is important because it indicates which regions may receive financial resources to generate human development more efficiently. This is a practically relevant finding, as it guides public policy makers on which Amazon regions should be prioritized to receive social spending. The justification for prioritizing these regions stems from their merit of being socially efficient. In other words, by applying public resources in these regions, human development in the Amazon region would accelerate through local wealth and social spending.

It is worth noting that only the microregion of one state capital is at the top of social efficiency (Rio Branco), while the microregions of other capitals did not achieve high rankings, such as Porto Velho (82nd position), Boa Vista (77th), Cuiabá (69th), Belém (51st), São Luís Urban Agglomeration (43rd), and Macapá (16th). This result shows that the microregions of the capitals do not have greater social efficiency than microregions in the interior of each state. Table 2 summarizes the Top-5 and Bottom-5 microregions in the analysis.

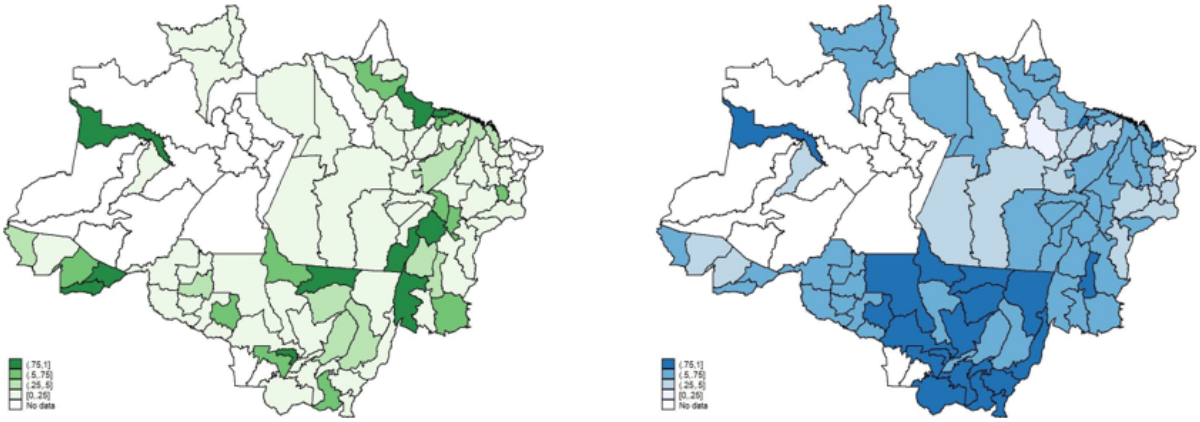
Table 2 | Top 5 and Bottom 5 Amazonian Microregions in Social Efficiency

Microregion	FU	IES	Rank SEI	HDI *(normalizad)*	Rank IDH	Changes Rank
Top-5 **microregion**						
Alto Paraguai	MT	1.0000	1	0.8102	13	-12
Arari	PA	0.8849	2	0.5060	68	-66
Brasiléia	AC	0.8744	3	0.5889	52	-49
Araguaína	TO	0.8716	4	0.6722	31	-27
Rio Branco	AC	0.8290	5	0.6054	46	-41
Bottom-5 **microregion**						
Gerais de Balsas	MA	0.0307	83	0.4586	78	5
Parauapebas	PA	0.0292	84	0.5873	53	31
Tucuruí	PA	0.0214	85	0.4659	77	8
Marabá	PA	0.0028	86	0.5434	59	27
Óbidos	PA	0.0000	87	0.6355	37	50

Source: Prepared by the authors.

The Bottom-5 microregions in social efficiency are: Gerais de Balsas (MA), Parauapebas (PA), Tucuruí (PA), Marabá (PA), and Óbidos (PA). Note that most of the least efficient microregions are concentrated in the state of Pará. Additionally, some of these regions have extractivism as their main productive activity, especially mining. As a result, these microregions receive substantial financial resources from the Financial Compensation for the Exploration of Mineral Resources (CFEM) (Borges; Borges, 2011). However, these regions are unable to use these resources efficiently to generate human development. This result indicates that these regions have been wasting public resources and local wealth in terms of generating human development. Note that there is a discrepancy between the Social Efficiency Index and the HDI. In fact, the correlation between the Social Efficiency Indicator (SEI) and the HDI was only 19.07% for the microregions analyzed. Several microregions with low human development indexes showed high performance in social efficiency. For example, the microregion of Arari (PA), where the SEI (0.8849) was much higher than the HDI (0.5060). The same occurred in other regions such as Sena Madureira (AC) [0.6819; 0.4789], Conceição do Araguaia (PA) [0.8051; 0.5248], Presidente Dutra (MA) [0.6323; 0.4859], and Brasiléia (AC) [0.8744; 0.5885]. These regions deserve recognition for effectively transforming social spending and local wealth into human development, despite having a low HDI. Figure 2 illustrates the difference between the Social Efficiency Index (2a) and the Human Development Index (2b), where darker colors indicate higher social efficiency or human development.

Figure 2 | Map of the Social Efficiency Index and HDI in the Amazon



a) Social Efficiency Indicator b) Human Development Indicator

Source: Prepared by the authors.

On the other hand, some regions showed a high HDI but low social efficiency performance. This is the case of Parecis microregion (MT), where the SES (0.1040) is much lower than the local HDI (0.91340). The same occurred for Cuiabá (MT) [0.1041; 0.8841], Alto Pantanal (MT) [0.1041; 0.8734], Médio Araguaia (MT) [0.1042; 0.7696], and Colorado do Oeste (RO) [0.0527; 0.7319]. Note that the predominance of microregions in the state of Mato Grosso presented social efficiency much lower than human development. This result demonstrates the distortion that analysis based on absolute indicators brings to the approach of social efficiency (Ferraz et al., 2020). In summary, the results of this article show that social efficiency is a relevant approach for the Amazon Region.

Note that these results are important for the local development of the Brazilian Legal Amazon. This is because the Social Efficiency Indicator provides valuable subsidies for the formulation of more effective public policies directed at local human development. Identifying microregions with higher Social Efficiency Index (SES) allows public managers to prioritize areas that demonstrate a greater capacity to transform financial and public resources into human development. This represents an important advance in budget allocation logic, since it is not just about identifying regions with low

development but investing in those that demonstrate merit in efficiency—that is, the capacity to generate positive social outcomes with the available resources. This approach maximizes the effects of public spending, accelerating human development in a strategic and effective way, based on quantitative evidence.

On the other hand, the identification of less efficient microregions, especially those concentrated in the state of Pará and strongly linked to mineral extractivism, reveals a worrying pattern of poor resource allocation. Therefore, local development can be fostered through public policies, namely: a) incentives for efficiency in local public management, aiming to reward and expand the administrative capacity of microregions with high Social Efficiency Index (SES), even when the HDI is low; b) Restructuring Plan for the Application of Mining Royalties (PRARM), to reformulate the use of resources from the Financial Compensation for Mineral Exploration (CFEM) in extractivist microregions with low social performance; and c) Policy for the Interiorization of Social Investments (PIIS), to redirect part of federal and state public investments to interior microregions with high efficiency potential, instead of concentrating resources in the capitals.

Additionally, it is noteworthy that the low correlation between SES and the Human Development Index (HDI) reinforces the need for policies based on efficiency and not just absolute development indicators. Microregions with low HDI but high SES show that it is possible to achieve expressive results in adverse contexts, serving as examples of good practices that should be valued and replicated. These evidences provide a new perspective for policymakers, highlighting that efficiency in the application of resources can be more decisive for progress than the mere availability of wealth.

In summary, only ten microregions (11.50%) are in the quartile representing the highest social efficiency (0.75 to 1.0). In contrast, 63.22% of the analyzed microregions (55 microregions) are located in the worst quartile of the efficiency ranking (0.0 to 0.25). This result reveals that, although there are socially efficient regions, most microregions in the Amazon Region can be considered socially inefficient (or of low efficiency). Moreover, the Human Development Index is unable to demonstrate these results, which positions the Social Efficiency Index (SES) as a powerful tool for public policymakers in the Amazon.

CONCLUSION

This study achieved the objective of measuring social efficiency and contributed by revealing the performance of 87 microregions in the Brazilian Amazon. Using social expenditures and wealth as inputs for 14 social variables, it was possible to present the Social Efficiency Index (SEI) and compare it with the traditional Human Development Index (HDI). In summary, this article revealed that the majority of microregions in the Amazon are socially inefficient. Moreover, only one state capital, Rio Branco (AC), ranked at the top of the social efficiency ranking. It is worth highlighting that the lowest positions in the efficiency ranking were occupied by microregions in Pará. Regions with high HDI but low social efficiency are concentrated in Mato Grosso.

The results presented are relevant for policymakers in the states that make up the Legal Amazon, as well as federal authorities and international organizations that provide financial resources for social development in the Amazon. This is because this study revealed the microregions with the greatest potential to use financial resources and local wealth efficiently. In other words, regions such as Alto Paraguai (MT) and Arari (PA) have been using financial resources adequately, demonstrating the capacity to generate better local human development. Additionally, microregions like Sena Madureira (AC) and Conceição do Araguaia (PA) have made good use of financial resources, although they present low levels of human development. In this respect, policymakers have an objective indicator to guide future social spending in the Amazon region.

Although this study has made contributions to the region, some limitations and future directions should be considered. First, only one microregion was analyzed in the state of Amazonas due to insufficient data for analysis of other microregions. Second, environmental information (deforestation, CO2 emissions, pollution, etc.) was not considered. Although this study focuses on social issues for the local population, environmental issues are relevant to the Amazon Region. Third, information about corruption was not included in the calculation of social efficiency. It is suggested that future studies consider reports of corruption in the use of public resources in the region. Finally, this study concludes that the economic and social development of the Amazon depends on the proper use of social expenditures and local wealth. This requires objective analytical tools for policymakers, such as the indicator presented in this article.

REFERENCES

ALKIRE, S.; FOSTER, J. Counting and multidimensional poverty measurement. *Journal of public economics*, Elsevier, v. 95, n. 7-8, p. 476–487, 2011.

ANGULO-MEZA, L.; LINS, M. P. E. Review of methods for increasing discrimination in data envelopment analysis. *Annals of Operations Research*, Springer, v. 116, n. 1, p. 225–242, 2002.

ATKINSON, A. B. Multidimensional deprivation: contrasting social welfare and counting approaches. *The Journal of Economic Inequality*, Springer, v. 1, p. 51–65, 2003.

BANKER, R. D.; CONRAD, R. F.; STRAUSS, R. P. A comparative application of data envelopment analysis and translog methods: an illustrative study of hospital production. *Management science*, INFORMS, v. 32, n. 1, p. 30–44, 1986.

BILBAO-UBILLOS, J. Another approach to measuring human development: The composite dynamic human development index. *Social indicators research*, Springer, v. 111, p. 473–484, 2013.

BORGES, Fabrini Quadros; BORGES, Fabricio Quadros. Royalties minerais e promoção do desenvolvimento socioeconômico: uma análise do projeto carajás no município de Paraupebas no Pará. **Planejamento e Políticas Públicas**, n. 36, 2011.

CHARNES, A.; COOPER, W. W.; RHODES, E. Measuring the efficiency of decision making units. *European journal of operational research*, Elsevier, v. 2, n. 6, p. 429–444, 1978.

COOK, W. D.; ZHU, J. Data envelopment analysis: A handbook of modeling internal structure and network. Springer, 2014.

DESPOTIS, D. K. A reassessment of the human development index via data envelopment analysis. *Journal of the operational research society*, Springer, v. 56, p. 969–980, 2005.

DOMÍNGUEZ-SERRANO, M.; BLANCAS, F. J. A gender wellbeing composite indicator: The best-worst global evaluation approach. *Social Indicators Research*, Springer, v. 102, p. 477–496, 2011.

DREZE, J.; SEN, A. *Hunger and public action*. [S.l.]: Clarendon Press, 1990.

FERRAZ, D.; MORALES, H. F.; CAMPOLI, J. S.; OLIVEIRA, F. C. R.; REBELATTO, D. A. N. Economic complexity and human development: DEA performance measurement in Asia and Latin America. *Gestão & Produção*, v. 25, n. 4, p. 839-853, 2018.

FERRAZ, D.; MARIANO, E. B.; REBELATTO, D.; HARTMANN, D. Linking human development and the financial responsibility of regions: Combined index proposals using methods from data envelopment analysis. *Social Indicators Research*, v. 150, p. 439-478, 2020.

FERRAZ, D.; ALVES, R. L.; VAZ, D. L.; SANTOS, V. S. Privação social e responsabilidade financeira no estado do Pará/Brasil. *Ouro Preto: Simpósio de Engenharia de Produção (SIENPRO)*, 2021.

FUKUDA-PARR, S.; LAWSON-REMER, T.; RANDOLPH, S. An index of economic and social rights fulfillment: concept and methodology. *Journal of Human Rights*, Taylor & Francis, v. 8, n. 3, p. 195–221, 2009.

GRIMM, M.; HARTTGEN, K.; KLASEN, S.; MISSELHORN, M. A human development index by income groups. *World Development*, v. 36, n. 12, p. 2527-2546, 2008.

HASHIMOTO, A.; ISHIKAWA, H. Using dea to evaluate the state of society as measured by multiple social indicators. *Socio-Economic Planning Sciences*, Elsevier, v. 27, n. 4, p. 257–268, 1993.

HERRERO, C.; MARTÍNEZ, R.; VILLAR, A. Multidimensional social evaluation: an application to the measurement of human development. *Review of Income and Wealth*, Wiley Online Library, v. 56, n. 3, p. 483–497, 2010.

IBGE. *Pesquisa de orçamentos familiares: 2017-2018: perfil das despesas no Brasil: indicadores selecionados*. Rio de Janeiro: IBGE, 2020. (ID: 101761). Descrição física: 110 p. ISBN 9786587201276.

Instituto Brasileiro de Geografia e Estatística (IBGE). *Censo Demográfico 2010*. Rio de Janeiro: [s.n.], 2010. <http://censo2010.ibge.gov.br>. Acesso: maio 2018.

IPAM. *A importância das florestas em pé*. 2024. Acesso em: 31 maio 2024. Disponível em: <https://ipam.org.br/cartilhas-ipam/a-importancia-das-florestas-em-pe-2/>.

MARIANO, E. B. *Progresso e Desenvolvimento Humano: Teorias e indicadores de riqueza, qualidade de vida, felicidade e desigualdade.* [S.l.]: Alta Books, 2019.

MARIANO, E. B.; REBELATTO, D. A. d. N. Transformation of wealth produced into quality of life: analysis of the social efficiency of nation-states with the dea's triple index approach. *Journal of the Operational Research Society*, Springer, v. 65, p. 1664–1681, 2014.

MARIANO, E. B.; SOBREIRO, V. A.; REBELATTO, D. A. do N. Human development and data envelopment analysis: A structured literature review. *Omega*, Elsevier, v. 54, p. 33–49, 2015.

MORAIS, P.; CAMANHO, A. S. Evaluation of performance of european cities with the aim to promote quality of life improvements. *Omega*, Elsevier, v. 39, n. 4, p. 398–409, 2011. 4

NUSSBAUM, M. C. *Women and human development: The capabilities approach*. [S.l.]: Cambridge university press, 2000. v. 3.

PNUD. *Human Development Report 2016: Technical Notes*. 2016. Acesso em: 31 maio 2024. Disponível em: <https://hdr.undp.org/en/2016-report>.

RANIS, G.; STEWART, F.; SAMMAN, E. Human development: beyond the human development index. *Journal of Human Development*, Taylor & Francis, v. 7, n. 3, p. 323–358, 2006.

RAVALLION, M. Troubling tradeoffs in the human development index. *Journal of development economics*, Elsevier, v. 99, n. 2, p. 201–209, 2012.

RIBEIRO, A. P.; SILVA, S. T.; GUIMARÃES, D. Macroeconomic fundamentals of poverty and deprivation: an empirical study for developed countries. *The European Journal of Development Research*, Springer, v. 27, p. 37–66, 2015.

RODRIGUES, D. L.; SILVA, D. N. Pobreza na amazônia brasileira e os desafios para o desenvolvimento. *Cadernos de Saúde Pública*, SciELO Brasil, v. 39, n. 10, p. e00100223, 2023.

ROMANO, T. d. A.; MASCARENHAS, A. d. N. Educação profissional e qualidade de vida do Amazonas (brasil). In: ISPA–INSTITUTO UNIVERSITÁRIO. *Actas do 12º Congresso Nacional de Psicologia da Saúde*. [S.l.], 2018. p. 805–812.

SAGAR, A. D.; NAJAM, A. The human development index: a critical review. *Ecological economics*, Elsevier, v. 25, n. 3, p. 249–264, 1998.

SEN, A. The concept of development. *Handbook of development economics*, Elsevier, v. 1, p. 9–26, 1988.

SEN, A. Development as freedom. *Development in Practice-Oxford-*, OXFAM, v. 10, n. 2, p. 258–258, 2000.

SILVEIRA, B. C.; SILVA, R. G. da; CARVALHO, L. de A. Índice relativo de qualidade de vida da região norte: uma aplicação da análise fatorial. *Revista Brasileira de Gestão e Desenvolvimento Regional*, v. 4, n. 4, 2008.

TOWNSEND, P. Deprivation. *Journal of social policy*, Cambridge University Press, v. 16, n. 2, p. 125–146, 1987.