Quantitative methods and analysis of health performance and environmental conditions in the city of Porto Velho: 6 years after the hydroelectric dams of Jirau and Santo Antônio, on the Madeira River

Carlos Alberto Paraguassu-Chaves[1], Allan Kardec Duailibe Barros Filho[2], Fabrício Moraes de Almeida[3], Lenita Rodrigues Moreira Dantas[4], Fabio Robson Casara Cavalcante[5], Carlos de Andrade Macieira[6], João Viana Fonseca Neto[7] Charlles da Silva Barata[8]

[1]PhD in Health Sciences - University of Brasília - UnB, Brazil; PhD in Science - University of Havana (Cuba); Post-Doctor in Health Sciences - UnB and Degli Studi D'Aquila University - IT. Professor at the Federal University of Maranhão, Brazil.
[2]PhD in Information Engineering. Universidade de Nagoya – Japan; Post-Doctor. The Institute of Physics and Chemistry (RIKEN), Japan. Professor at the Federal University of Maranhão, Brazil.
[3]PhD in Physics (UFC), with post-doctorate in Scientific Regional Development (DCR/CNPq). Researcher of the Doctoral and Master Program in Regional Development and Environment (PGDRA/UNIR). Leader of line 2 - Technological and Systemic Development, and Researcher of GEITEC ― Federal University of Rondônia, Brazil.
[4] Graduated and Specialist in Geography. Graduated in Law. Researcher at the Higher Institute of Health Sciences and Environment of the Amazon – AICSA, Brazil.
[5]PhD in Sciences: Socio-environmental development - NAEA / UFPA. Associate Professor, Federal University of Rondônia – UNIR.
[6]Specialist in Internal Medicine and Nephrology - Federal University of Rio de Janeiro, Brazil. Nephrologist at the University Hospital of the Federal University of Maranhão – HUUFMA, Brazil.
[7]PhD in Electrica Engineering. Federal University of Paraíba, Brazil. Professor at the Federal University of Maranhão, Brazil.
[8]Master in Geography - Federal University of Rondônia. Researcher at the Higher Institute of Health Sciences and Environment of the Amazon – AICSA.

ABSTRACT

Objective: *to analyze the IQVU of the city of Porto Velho, Rondônia, Brazil, in a perspective of quality of life from the construction of the UHEs on the Madeira River.* ***Methods:*** *the model developed by Paraguassú-Chaves et al [3] was used to analyze the performance index in health and environmental conditions. 552 forms and interviews were applied, which contributed to the collection of primary data in the sample survey in the 69 neighborhoods grouped by the four urban areas of Porto Velho, involving 8 households per neighborhood. The data were submitted to Factor Analysis to calculate the quality of life indexes. In the analysis phase, the IQVU model of the Hair et al classification index scale [4] was used.* ***Results:*** *After 6 years, the quality of life indexes found in this research are similar to those found previously.*

Central Zone IQVU (0.456) Regular, East Zone IQVU (0.406), North Zone IQVU (0.428) and South Zone IQVU (0.393), with the average IQVU (0.420) of the city of Porto Velho. ***Conclusions:*** *there was a significant drop in the quality of life index with the construction of the Jirau and Santo Antônio hydroelectric dams on the Madeira River, in Porto Velho. The city's quality of urban life index, which had already suffered a negative impact during the construction of the dams and 1 year later, worsened six years later.*

Keywords *- Health and Environment. IQVU. Hydroelectric dams. Porto Velho. Western Amazon.*

I. INTRODUCTION

The scenarios of the Brazilian Amazon have always been linked to the perspectives of regional development. The construction of the Jirau and Santo Antônio hydroelectric dams mobilized the city of Porto Velho and the state of Rondônia, in the Western Amazon. The projection of two hydroelectric dams defined by the central government of Brazil, through the Federal Government's Growth Acceleration Program - PAC, meets an emerging demand from the electricity sector for the country. A model of public policies for regional and local development to serve Brazil as a whole.

During the process of issuing environmental licenses for the construction of two large hydroelectric plants and in public hearings, several debates were held on the projects of the Jirau and Santo Antônio hydroelectric plants. Environmental impacts, issues of indigenous and riverside communities, conservation and preservation of fauna and flora, among many other issues, were widely discussed by different segments of local society, federal, state and municipal government, construction companies and consortia of interested companies.

However, the agenda related to the impact on people's lives was not a priority in the discussions. Priority was given to riverside areas, conservation units, fauna, flora and other factors considered important for society. At no stage of the process was there concern with the diagnosis or prognosis of the quality of urban life in Porto Velho.

The official and unofficial advertising of the companies responsible for the construction of hydroelectric dams, the official announcement by the federal government and the state government and the municipal government only disclosed the beneficial effects that the projects would bring to the city and the municipality of Porto Velho, for the state of Rondônia and for Brazil. What was known was that since the beginning of the licensing process for hydroelectric dams and after the construction of UHE's, there was a significant sociocultural impact and a decrease in the urban quality of life index (IQVU) in the city of Porto Velho. The intense migratory flow of people in search of jobs, migrants from all regions of Brazil and other municipalities in Rondônia, boosted the life of the city of Porto Velho.

The starting point of the research is to understand the perception of the quality of life of the residents of the city of Porto Velho from the health and environmental conditions, before the construction of the hydroelectric dams of Jirau and Santo Antônio on the Madeira River, after construction and 6 years after. According to scientific literature, the increase in the migratory flow of workers to a city results in increased demand and pressure on basic and essential public services.

In the scenario of the arrival of a large human contingent in a city without proper infrastructure and essential services, the current shortage or insufficiency of such services is aggravated. In this case, it is possible to highlight the supply of treated water, the absence or inadequacy of garbage collection and domestic sewage services, public security services, transport, education and health care for the population. The migration process resulting from the hydroelectric dams on the Madeira River stimulated the arrival of thousands of people in Porto Velho, the main region of impacts of these projects. This migratory flow ended up stimulating new demands for essential social services.

The approach chosen to evaluate the health and environment parameters was the analysis of the quality of urban life in the city of Porto Velho, in the perception of its inhabitants about the quality of personal life and the quality of life in the city of Porto Velho (IQVU de Porto Velho).

The analysis model is the quality of life developed by Santos and Martins [1], in two different moments: in the initial phase of implementation of the Jirau and Santo Antônio hydroelectric projects; during the first year of implementation and operation of the two hydroelectric plants, based on the findings of Silva [2] and data found six years later, using the model of analysis of the performance index in health and environmental conditions, developed by Paraguassú-Chaves *et al* [3].

One question prompted the research. Did the hydroelectric dams on the Madeira River, in Porto Velho - Rondônia, contribute positively or negatively to the IQVU in the city of Porto Velho? Can the health and environment parameters of the Santos e Marins [1] model answer this question? The health and environmental conditions performance index (IDCSA) model developed by Paraguassú-Chaves *et al* [3] can corroborate the previous findings. Based on this issue, the work aimed to analyze the IQVU of the city of Porto Velho, Rondônia, Brazil, in a perspective of quality of life from the construction of the UHE's on the Madeira River.

II. METHODS

Silva's research [2] used the quality of life analysis model developed by Santos and Martins [1], which is based on four main domains: Environmental Conditions; Conditions of collective materials; Economic conditions and conditions of society. 6 years later the model of construction of the index of health performance and environmental conditions (IDCSA) developed by Paraguassú-Chaves *et al* [3] was used.

In this research, health service quality indicators and the environmental conditions of the Paraguassú-Chaves *et al* model [3] were measured. 552 forms and interviews were applied, which contributed to the collection of primary data in the sample survey in the 69 neighborhoods, grouped by the four urban areas of Porto Velho.

The tables were built using the SPSS program, version 22, based on the primary research data. The Urban Quality of Life Index - IQVU was calculated according to the Factor Analysis techniques presented by Hair *et al.* [4], Santana [5], [6] and Cavalcante [7].

2.1 Analytical Research Model

Method: Method of construction of the Urban Life Quality Index (IQVU).

The method used in this study followed the logic of factorial analysis, which can be seen in the matrix form as in Dillon and Goldstein [8]:

$$X\=\alpha F\+\varepsilon \; X\=\alpha F\+\varepsilon \quad (1)$$

Then:

X = is the p-dimensional vector transposed from observable variables, denoted by $X = (x_1, x_2,..., x_p)$;

F = is the q-dimensional vector transposed from non-observable variables or latent variables called common factors, denoted by $F = (f_1, f_2,..., f_q)$, where q < P;

ε = is the p-dimensional vector transposed from random variables or unique factors, denoted by $\varepsilon = (e_1, e_2,..., e_p)$;

α = is the array (p, q) of unknown constants, called factorials loads.

According to Gama *et al* [9], Santana [10], in the factorial analysis model it is assumed that specific factors are orthogonal, among themselves, with all common factors. Normally, E (ε) = E (F) = 0 and Cov (ε, F) = 0.

According to the authors, the initial structure used to determine the array of factorials loads, in general, may not provide a significant pattern of variable loads, so it is not definitive. This initial structure can be done by several methods of rotation of the factors, as Dillon and Goldstein [8], Johnson and Wichern [11]. It was used the VARIMAX method of orthogonal rotation of the factors for this study.

The VARIMAX method is a process where the reference axes of the factors are rotated around the source until some other position is reached. The objective is to redistribute the variance of the first factors to others and to achieve a simpler and more theoretically significant factorial [4], [6], [8], [9], [10], [11].

The choice of factors was carried out through the technique of latent root. So, the array of factorials loads, which measures the correlation between the common factors and observable variables, is determined by means of the correlation matrix, as Dillon and Goldstein [8].

To determine the Urban Quality of Life Index (IQVU), the matrix of factor scores estimated by the factorial rotation process through the orthogonal basis was used, as pointed out by Santana [10]. The factorial score puts each observation in the gap of the common factors. For each factor f_j, the i-th factor score extracted factorial score is defined by F_{Ij}, expressed as follows [8]:

$$F_{IJ}\=\mathbf{b_1}x_{i\1}\+\mathbf{b}_2x_{i\2}\+\mathrm{b}_px_{\mathrm{ip}}\; F_{IJ}\=\mathbf{b_1}x_{i\1}\+\mathbf{b}_2x_{i\2}\+\mathrm{b}_px_{\mathrm{ip}} \quad (2)$$

Then:

b_i = are the estimated regression coefficients for the n Common factorials scores;

x_{Ij} = Are the n Observations of p Observable variables.

i = 1.2,...N.

j = 1,2,...,p.

To reach the equation that is the perception index [9], [10], show the sequence evolution of the formulas from the previous equation. It turns out that even if the variable F_{Ij} is not observable it can be estimated through the factorial analysis techniques, using the matrix of observations of the vector x of observable variables. In factorial notation, equation 2 becomes:

$$F_{(n\,q)}\=X_{(n\,q)}b_{(p\,q)}\; F_{(n\,q)}\=X_{(n\,q)}b_{(p\,q)} \quad (3)$$

In Equation 3, *F* is the matrix of the estimated regression from the *n* Factorials scores and it can be affected by both the magnitude and the measurement units of the variables *x*. To work around this kind of problem, replace the variable *x* by the standard variable *w*, given the ratio of the deviation around the average and the standard deviation of *x*, as follows:

$$\frac{x_i - \bar{x})}{S_x}$$

With these values, Equation 3 is modified making equation 4 possible, then:

$$F_{(n\backslash q)}\backslash = w_{(n\backslash q)}\beta_{(p\backslash q)}\, F_{(n\backslash q)}\backslash = w_{(n\backslash q)}\beta_{(p\backslash q)} \quad (4)$$

Based on equation 4, the beta weights matrix (β) with *q* standardized regression coefficients, replaces *b*, given that the variables are standardized on both sides of the equation. Pre-multiplying both sides of equation 4 by the value $\frac{1}{n}\frac{1}{n}w'$, in which *n* Is the number of observations and *W* is the transposed matrix of *w'*, it makes it possible to reach the following equation:

$$\frac{1}{n}\, w'_{(p,n)}\, F_{(n,q)} = \frac{1}{n}\, w'_{(p,n)}\, w_{(n,p)}\, \beta_{(p,q)} = R_{(p,p)}\, \beta_{(p,q)} \quad (5)$$

The Matrix $\frac{1}{n}\frac{1}{n}w'w$, therefore is the matrix of intercorrelated variables or correlation matrix among the observations of the matrix *x*, designated by R. The Matrix $\frac{1}{k}w'F\ \frac{1}{k}w'F$ It represents the correlation between the factorials scores and the factors themselves, denoted by Λ. With this, rewriting the equation 5, one must:

$$\Lambda_{(p\backslash q)}\backslash = R_{(p\backslash p)}\beta_{(p\backslash q)}\, \Lambda_{(p\backslash q)}\backslash = R_{(p\backslash p)}\beta_{(p\backslash q)} \quad (6)$$

If the matrix R is non-singular, one can pre-multiply both sides of equation 6 by the inverse of R, obtaining:

$$\backslash\beta\backslash = \mathbf{R}^{-1}\Lambda\ \backslash\beta\backslash = \mathbf{R}^{-1}\Lambda \quad (7)$$

Substituting the β vector into equation 4, we obtain the factorial score associated with each observation, as follows:

$$F_{(n\backslash q)}\backslash = w_{(n\backslash p)}R^{-1}_{(p\backslash p)}\Lambda_{(p\backslash q)}\, F_{(n\backslash q)}\backslash = w_{(n\backslash p)}R^{-1}_{(p\backslash p)}\Lambda_{(p\backslash q)} \quad (8)$$

The main formula of the perception index is reached where the IP is defined as a linear combination of these factorials scores and the proportion of the variance explained by each factor in relation to the common variance. The mathematical expression is represented by the following formula:

$$\mathbf{IP}_i = \sum_{j\backslash=1}^{q}\left(\frac{\lambda_j}{\sum_j \square\, \lambda_j}\mathrm{FP}_{ij}\right)\mathbf{IP}_i = \sum_{j\backslash=1}^{q}\left(\frac{\lambda_j}{\sum_j \square\, \lambda_j}\mathrm{FP}_{ij}\right) \quad (9)$$

Then:

i = 1.2,...n.

λ = is the variance explained by each factor;

∑ λ = is the total sum of the variance explained by the set of common factors.

The factorial score was standardized (FP) to obtain positive values from the original scores and allow the hierarchies of the cities as the values of the performance index are located between zero and one. The formula that allows this tiering can be seen by the following equation:

$$FP_i = \left(\frac{F_i - F_{min}}{F_{max} - F_{min}}\right)$$

It can be seen that F_{min} F_{min} And F_{max} F_{max} are the maximum and minimum values observed for the factorial scores associated with the parameters observed. It is based on this understanding that it was possible to calculate the Urban Quality of Life Index (IQVU) adopted in this study.

The scaling of indices is based on the model by Hair *et al* [4]. The classification scale of the Porto Velho quality of life indexes follows the scale: 0.000 to 0.200 scale (Description: Terrible IQVU); 0.201 to 0.400 (Description: Bad IQVU); 0.401 to 0.600 (Description: Regular IQVU); 0.601 to 0.800 (Description: Good IQVU) and 0.801 to 1.000 (Description: Excellent IQVU). This same scale has already been applied in several studies in the Amazon context, como Environmental Education Perception Index (IPEA) headed for sustainable development: A Study in primary schools in the city of Guajará-Mirim, Rondônia (Brazil), de Paraguassu-Chaves; Cavalcante; Claro, *et al* [11]; and Factor Analysis and the Social Capital Index: A Study at the Brazil / Bolivia Border, de Paraguassú-Chaves; Cavalcante; Almeida, *et al* [12], and Cavalcante [7].

2.2 Scale Levels

The classification used by the research to express the results achieved by the IQVU is described in table 1.

Table 1: Analysis scale adopted by the research.

Scale	Description IQVU	Color representation
0.000 a 0.200	Terrible	
0.201 a 0.400	Bad	
0.401 a 0.600	Regular	
0.601 a 0.800	Good	
0.801 a 1.000	Great	

Source: Own Elaboration

2.3 Parameters and Indicators

The questionnaire used is structured with two parameters and 18 indicators. The first parameter aimed to identify health performance, the second to identify environmental conditions.

Table 2: Parameters and indicators (model created by Paraguassú-Chaves *et al* [3])

Parameter	Indicators
Health Perfomance	Number of Health Units (Hospitals, Health Center, Mixed Health Units). Geographic distribution of health facilities (spatial distribution by neighborhood and zone). Levels of health care (primary, secondary or tertiary). Access to public health service. Waiting time for medical care. Free medication distribution. Degree of satisfaction with the services provided by the public service. The public health service has improved in the last 6 years. Number of health professionals in health facilities (sufficient to meet the population's demand). Public health expenditure per capita. Adequate equipment to meet the population's demand (x-ray, mammography, tomography, magnetic resonance, dental equipment). Number of hospital beds. Laboratory equipment and tests.
Environmental Performance	Households with water supply. Households with garbage collection. Households with sewage. Garbage collection, transportation and final destination. Number of people consuming untreated water.

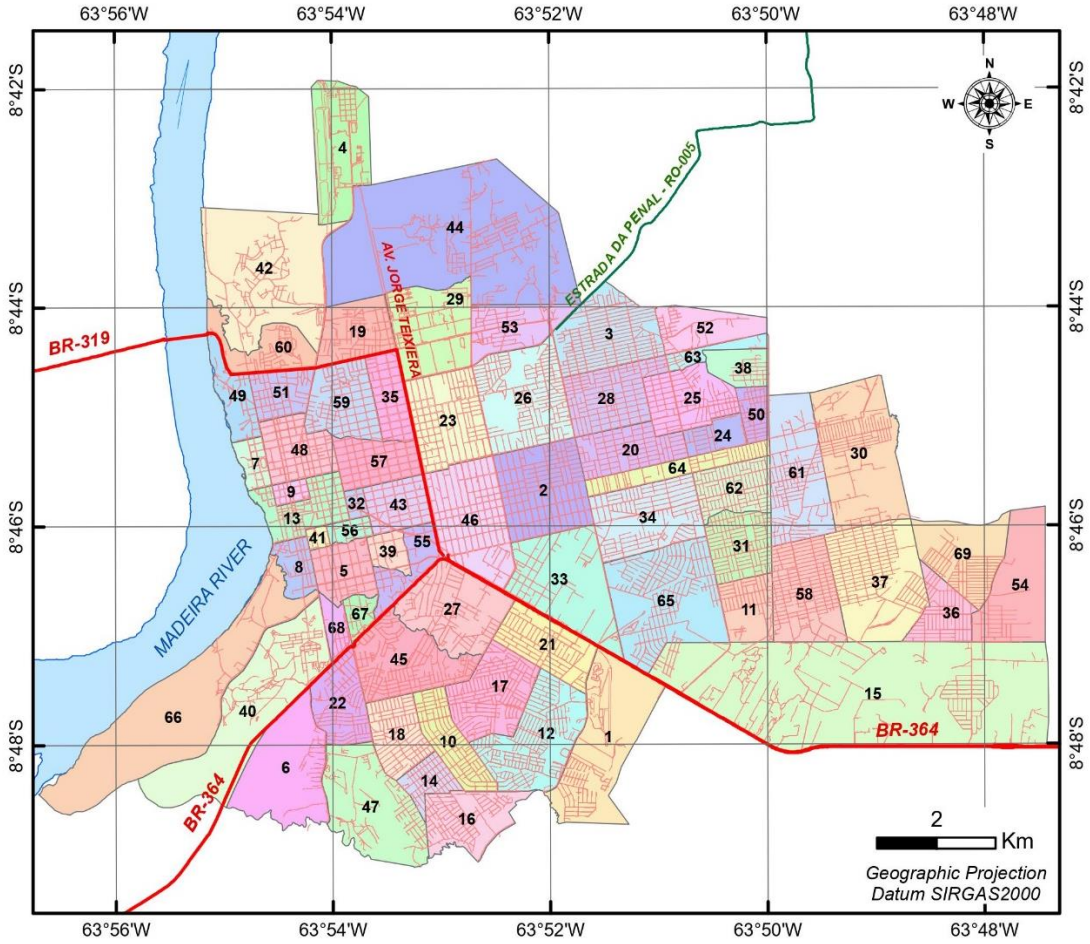
Source: Paraguassú-Chaves *et al* [3].

2.4 Ethical aspects

Some criteria were considered for the selection of the research subjects / interviewees: living in the city for at least two years; being of age; be the head of the family and who accepted to participate in the research as a volunteer. After signing the Informed Consent Form (ICF), the questionnaire and the interview were applied [14]. The questionnaire was applied by 5 field researchers, collaborators of the research group coordinated by Doctor Paraguassú-Chaves.

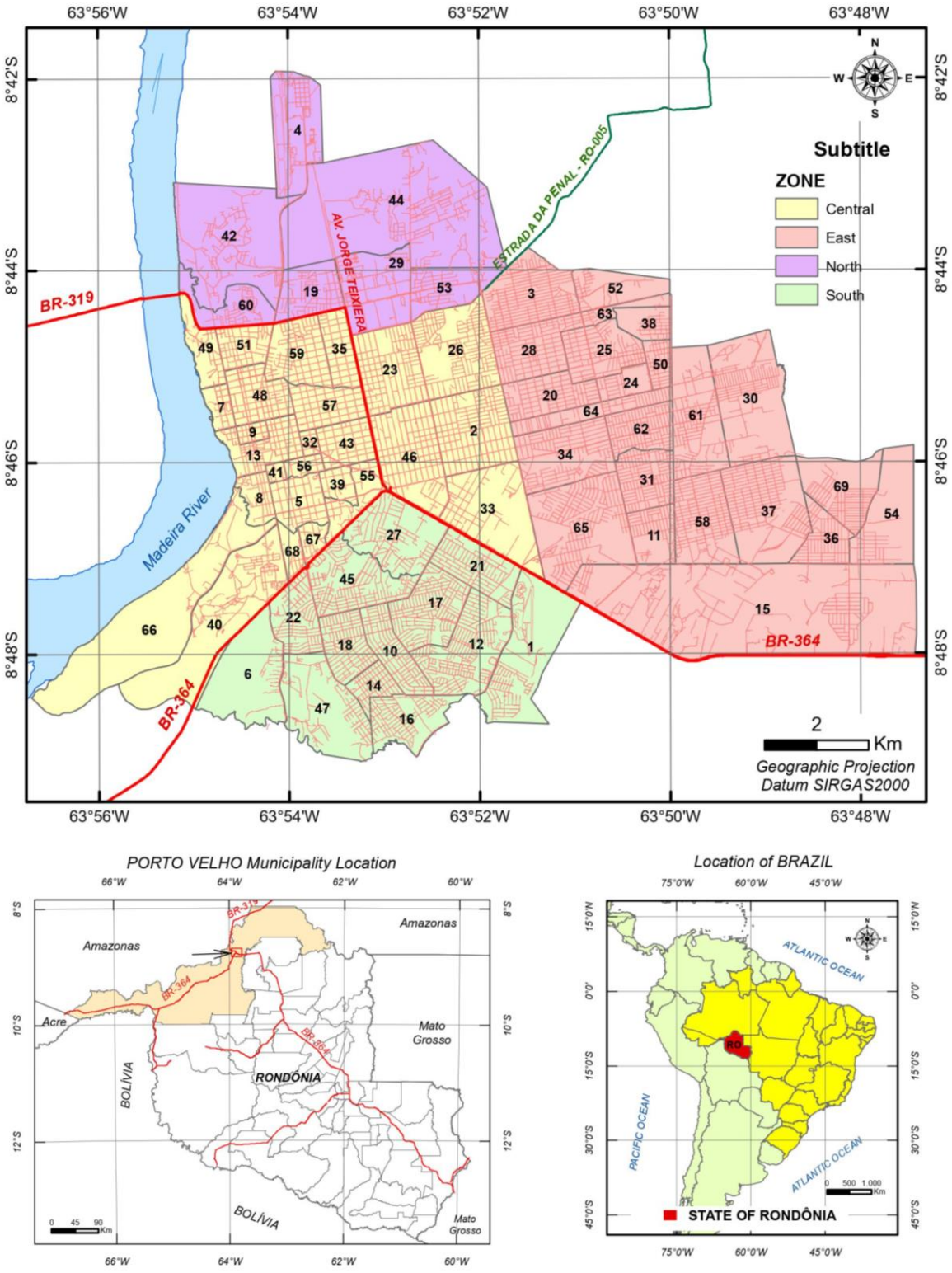
This work took into consideration the four zones of the urban perimeter (Central zone, East zone, North zone and South zone).

Map 1*:* Geographic Location and Division of Urban Areas of Porto Velho.



ORDER	NEIGHBORHOODS	ORDER	NEIGHBORHOODS	ORDER	NEIGHBORHOODS	ORDER	NEIGHBORHOODS
1	AEROCLUBE	19	COSTA E SILVA	37	MARIANA	55	ROQUE
2	AGENOR DE CARVALHO	20	CUNIÃ	38	MARINGÁ	56	SANTA BARBARA
3	APONIÃ	21	ELDORADO	39	MATO GROSSO	57	SÃO CRISTOVÃO
4	ÁREA MILITAR E AEROPORTO	22	ELETRONORTE	40	ÁREA MILITAR (5º BEC)	58	SÃO FRANCISCO
5	AREAL	23	EMBRATEL	41	MOCAMBO	59	SÃO JOÃO BOSCO
6	AREIA BRANCA	24	ESCOLA DE POLÍCIA	42	NACIONAL	60	SÃO SEBASTIÃO
7	ARIGOLÂNDIA	25	ESPERANÇA DA COMUNIDADE	43	NOSSA SENHORA DAS GRAÇAS	61	SOCIALISTA
8	BAIXA DA UNIÃO	26	FLODOALDO PONTES PINTO	44	NOVA ESPERANÇA	62	TANCREDO NEVES
9	CAIARI	27	FLORESTA	45	NOVA FLORESTA	63	TEIXEIRÃO
10	CALADINHO	28	IGARAPÉ	46	NOVA PORTO VELHO	64	TIRADENTES
11	CASCALHEIRA	29	INDUSTRIAL	47	NOVO HORIZONTE	65	TRÊS MARIAS
12	CASTANHEIRA	30	JARDIM SANTANA	48	OLARIA	66	TRIÂNGULO
13	CENTRO	31	JUSCELINO KUBITSCHEK	49	PANAIR	67	TUCUMANZAL
14	CIDADE DO LOBO	32	KM 1	50	PANTANAL	68	VILA TUPI
15	CIDADE JARDIM	33	LAGOA	51	PEDRINHAS	69	ULISSES GUIMARÃES
16	CIDADE NOVA	34	LAGOINHA	52	PLANALTO		
17	COHAB	35	LIBERDADE	53	RIO MADEIRA		
18	CONCEIÇÃO	36	MARCOS FREIRE	54	RONALDO ARAGÃO		

Map 2*:* Neighborhoods by Zone in the City of Porto Velho.



III. RESULTS AND DISCUSSION

3.1 Health and environment parameters for neighborhoods in the urban areas of the city of Porto Velho, 6 years after the construction of two large hydroelectric dams on the Madeira River.

In the Centro zone, the Nova Porto Velho neighborhood was the only one that maintained the IQVU Bom due to the scale adopted in the survey, which represented only 3.85% of the neighborhoods in that Zone. In an opposite situation, the Militar and Lagoa neighborhoods remained in penultimate and last place, respectively in both scenarios, according to Silva's research [2] before the construction of the dams and 1 year later. (table 3).

The vast majority of neighborhoods (86.46%), in turn, remained on the IQVU Regular scale in both scenarios for this health and environment parameter. Before the dams of the UHE and 1 year later, of the total of 26 neighborhoods, 23 had regular IQVU and only 1 had good IQVU.

Six years after Silva's research [2], of the 26 neighborhoods that make up the Zona Centro, 23 neighborhoods remain with IQVU between 0.401 - 0.600, considered by the scale adopted in the research as Regular, 1 with IQVU Good of 2 with IQVU Bad (between 0201 - 0.400).

The neighborhood of Nova Porto Velho is the only one that remained IQVU Good in both periods and after 6 years it maintains the IQVU Good.

The neighborhood of Agenor de Carvalho decreased from the index of 0.600, in the scenario before the hydroelectric dams, to 0.402 in the scenario 1 year after the construction of the UHE's and decreased to 0.401, 6 years later.

The explanation for this drop in quality of life can be seen by the severity of the residents' assessment in relation to the current scenario for the criteria of available green spaces, precarious public cleaning service, urban and rural pollution, inefficiency of the public health service, difficulty in obtaining medical assistance, identified by 95.24% of the interviewees as Bad in each of these aspects, as announced by Silva [2] and corroborated in this study. The IQVU average is maintained with a Regular performance index.

Table 3: Health and Environment Parameters by Neighborhoods in the Central Zone (IQVU).

Neighborhood	Before	1 year later	6 years later
Nova Porto Velho	0.671	0.669	0.670
Agenor de Carvalho	0.600	0.402	0.401
K1	0.558	0.555	0.553
São João Bosco	0.554	0.553	0.559
Olaria	0.546	0.545	0.548
Baixa União	0.532	0.531	0.528
Santa Bárbara	0.523	0.521	0.521
Flodoaldo Pinto	0.519	0.519	0.518
N. Sra. das Graças	0.517	0.514	0.516
Roque	0.516	0.514	0.511
Tucumanzal	0.502	0.500	0.497
Embratel	0.500	0.500	0.495
Panair	0.498	0.492	0.496
Tupi	0.486	0.483	0.480
Caiari	0.476	0.472	0.480
Triangulo	0.476	0.476	0.469

Liberdade	0.475	0.473	0.472
Mato Grosso	0.472	0.470	0.466
Centro	0.451	0.450	0.447
Arigolândia	0.450	0.449	0.455
Mocambo	0.441	0.439	0.437
Pedrinhas	0.425	0.424	0.430
Areal	0.413	0.410	0.408
São Cristovão	0.409	0.408	0.400
Militar	0.389	0.388	0.390
Lagoa	0.376	0.371	0.370
IQVU	0.491	0.481	**0.456**

Source: search result.

In the East Zone, 13.04% of the neighborhoods had IQVU Good and only 4.35% with IQVU Bad in the phase prior to the hydroelectric plants. After the construction of the UHE's, in general, all neighborhoods decreased their quality of life indexes. The scenario changed completely with 52% of the neighborhoods with IQVU Regular and 48% with IQVU Bad. A decline in the quality of life in this area. All neighborhoods in the Zone lose quality in the health and environment indicators of the Environmental Conditions Domain of the Matrix of Indicators of Quality of Urban Life - IQVU.

One year after the construction of the UHE's, no neighborhood was found with the IQVU Bom. The neighborhood Escola de Polícia decreased from the index of 0.700 considered Good IQVU to 0.581 considered Regular. The same occurs with the Socialista (IQVU 0.674) and Igarapé (IQVU 0.646) neighborhoods, which decrease to (IQVU 0.296) and (IQVU 0.370), respectively, considered Bad indexes. Six years later, of the 23 neighborhoods that make up the East Zone, 43% have IQVU Regular and 57% Bad, that is, 10 neighborhoods have IQVU Regular (IQVU less than 0.600) by the scale adopted and 13 neighborhoods with IQVU Bad (less than 0.400). Only the neighborhoods of the São Francisco, Police School, Juscelino Kubitshek, Tancredo Neves, Marcos Freire, Tiradentes, Mariana, Cidade Jardim, Cascalheira and Planalto remain with the IQVU Regular. All other neighborhoods are in the IQVU Bad rating range. There was a significant drop in the quality of life in these neighborhoods (table 4).

Table 4: Health and Environment Parameters by East Zone Neighborhoods (IQVU).

Neighborhood	Before	1 year later	6 years later
Escola de Polícia	0.700	0.581	0.572
Socialista	0.674	0.295	0.299
Igarapé	0.646	0.370	0.380
Lagoinha	0.594	0.321	0.333
Jardim Santana	0.584	0.388	0.387
Pantanal	0.584	0.404	0.399
Planalto	0.584	0.404	0.410

Mariana	0.577	0.421	0.435
Juscelino Kubitschek	0.564	0.519	0.522
Cascalheira	0.559	0.416	0.437
Tiradentes	0.555	0.422	0.440
Tancredo Neves	0.550	0.498	0.488
Cidade Jardim	0.546	0.448	0.451
Marcos Freire	0.540	0.477	0.483
Ronaldo Aragão	0.529	0.339	0.337
Três Marias	0.523	0.405	0.399
Aponiã	0.520	0.339	0.339
Cunhã	0.517	0.348	0.340
Ulisses Guimarães	0.516	0.339	0.325
Maringá	0.513	0.397	0.367
Teixeirão	0.513	0.397	0.380
São Francisco	0.487	0.526	0.521
Esp. Comunidade	0.342	0.318	0.311
IQVU	**0.529**	**0.407**	**0.406**

Source: search result.

In the North Zone, in general, there was a worsening in the scenario of this Zone, where it was possible to verify that the reduction from 85.71% to 57.14% of the neighborhoods in the situation considered Regular IQVU, in the corresponding period before and after 1 year of construction of UHE's. There was an increase from 14.29% to 42.86%, in the same period, for the situation that indicated IQVU Bad after the construction of UHE's. The neighborhoods Rio Madeira, São Sebastião and Costa e Silva remain in the IQVU Regular before and 1 year after the construction of UHE's. The National, Military and New Hope neighborhoods descend to the IQVU Bad, results found by Silva [2] and confirmed by the sample presented by Paraguassú-Chaves [15]. (table 5).

Six years later, of the 7 neighborhoods that make up the North Zone of the city of Porto Velho, 4 (57%) neighborhoods remain classified with Regular IQVU (Rio Madeira, Industrial, São Sebastião and Costa e Silva) and 3 (43%) remain with IQVU Bad (National, Military and New Hope).

Table 5: Health and Environment Parameters by Neighborhoods in the North Zone (IQVU).

Neighborhood	Before	1 year later	6 years later
Rio Madeira	0.528	0.568	0.579
Nacional	0.476	0.368	0.353
São Sebastião	0.466	0.439	0.427
Nova Esperança	0.461	0.341	0.342

Costa e Silva	0.431	0.432	0.440
Área Militar	0.426	0.341	0.386
Industrial	0.380	0.446	0.469
IQVU	**0.452**	**0.419**	**0.428**

Source: search result.

In the South Zone, there was a negative increase in quality of life. In the period prior to the UHE's, it was observed that 30.76% of the neighborhoods had IQVU Good, 53.4 IQVU Regular and just over 15% IQVU Bad. Thus, the neighborhoods Cidade Nova, Novo Horizonte, Castanheiras and Aeroporto presented themselves with the IQVU Bom before the construction of the UHE's. In a year after the construction of the dams, none of the neighborhoods has a good performance index. There has been a significant decrease in the quality of urban life in this Zone.

In this area, neighborhoods with low IQVU (between 0201 and 0.400 considered a low performance index) increased from 15% to 61.53%, after the UHE's [2]. (table 6). These findings by Silva [2] are proportional to those found 6 years later, according to Paraguassú-Chaves [15]. Six years later, of the 13 neighborhoods in the South Zone, 7 (53%) have IQVU Regular (Aeroclube, Novo Horizonte, Cidade Nova, Caladinho, Castanheira, Cidade do Lobo and Eletronorte) and 6 with IQVU Bad.

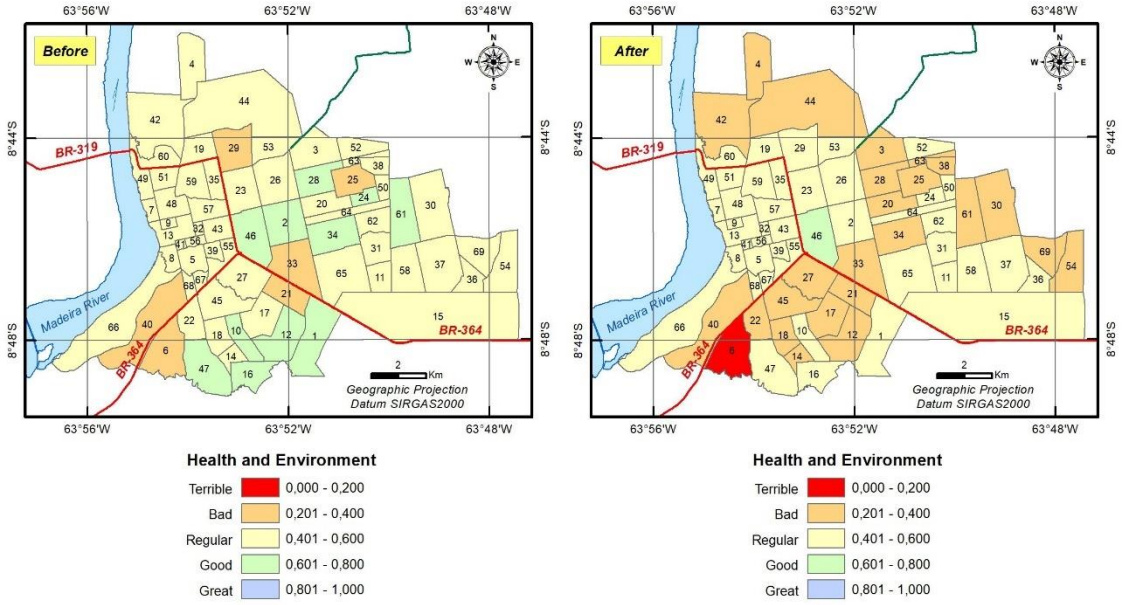
Table 6: Health and Environment Parameter by Neighborhoods in the South Zone (IQVU).

Neighborhood	Before	1 year later	6 years later
Cidade Nova	0.661	0.484	0.496
Novo Horizonte	0.649	0.512	0.500
Castanheira	0.644	0.362	0.444
Aeroclube	0.602	0.564	0.580
Caladinho	0.586	0.418	0.473
Cidade do Lobo	0.557	0.288	0.412
Eletronorte	0.534	0.275	0.404
Cohab	0.530	0.270	0.338
Floresta	0.478	0.339	0.341
Conceição	0.446	0.273	0.297
Nova Floresta	0.418	0.244	0.309
Eldorado	0.377	0.294	0.298
Areia Branca	0.373	0.108	0.222
IQVU	**0.527**	**0.340**	**0.393**

Source: search result.

Cartogram 1, below, shows the result of the Health and Environment index for all Zones of Porto Velho corresponding to the scenario that indicates the before and after the arrival of UHE's on the Madeira River presented by Silva [2] similar to cartogram 6 yeas later.

Cartogram 1: IQVU by neighborhoods in the city of Porto Velho.



3.2 Analysis of Health and Environment Parameters by Urban Areas in the City of Porto Velho.

For the Health and Environment parameter, table 7 and cartogram 2 demonstrate the performance of this parameter for the four Zones of the urban perimeter of the city of Porto Velho. Before the UHE's, the 4 Zones presented a performance consideret regular.

According to Silva [2], after UHE's there was a worsening of IQVU. The South Zone decreases from Regular to Bad performance. All zones also undergo changes in the IQVU. The index rating scale values decreased from the first phase to phase 1 years after the UHE's: East from 0.529 to 0.407; Center from 0.491 to 0.481; South from 0.527 to 0.340 and North from 0.452 to 0.419. The 4 Zones, in general are in the same class of paramenter analyzed (IQVU Regular), wint the exception of the South Zone [2]. (table 7 and cartogram 2).

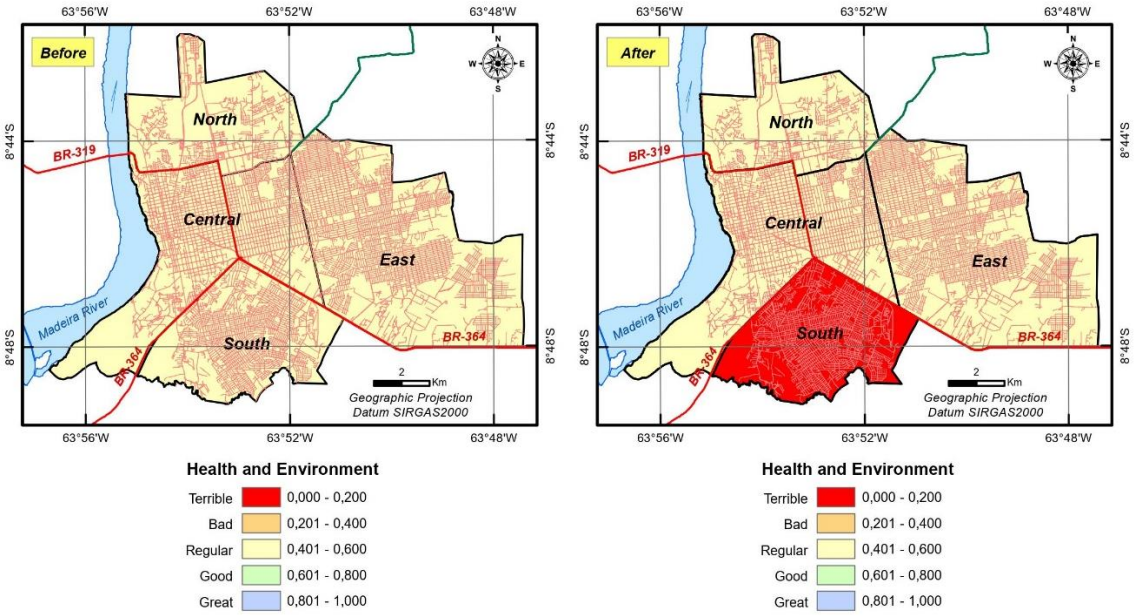
After 6 years, the quality of life indexes found in this research are similar to those found previously. Central Zone IQVU (0.456) Regular, East Zone IQVU (0.406), North Zone IQVU (0.428) and South Zone IQVU (0.393), with the average IQVU (0.420) of the city of Porto Velho.

Table 7: Health and Environment Parameter by Zone (IQVU).

ZONE	Before	After	6 years later
EAST	0.529	0.407	0.406
SOUTH	0.527	0.340	0.393
CENTRAL	0.491	0.481	0.456
NORTH	0.452	0.419	0.428
IQVU	**0.499**	**0.411**	**0.420**

Source: search result.

Cartogram 2: Health and Environment Parameter by Zone.



The discussion on the environmental issue is historical and endowed with a lot of rhetoric, especially when it comes to the urban environment [16]. Several aspects such as pollution, contamination of soil and water, the irregular occupation of urban soil, are stages of discussions. Other manifestations, such as natural disasters as a result of human action in cities, have been much discussed. In the city of Porto Velho, the precarious public services of basic sanitation, sewage, the inefficient collection and disposal of garbage, poor public lighting, streets without adequate infrastructure, violence, traffic problems, precarious health services and other problems are a reality in a city of the Amazon.

One of the environmental and public health problems is the collection and final destination of domestic solid waste. In the city of Porto Velho, urban waste is still deposited in a landfill consisting of cells from waste deposits owned by the Porto Velho municipal government.

The lack of a landfill in itself is already a sanitary, environmental and public health problem. According to Silveira [17] in a work under the guidance of Dr. Paraguassú-Chaves, one of the major environmental and health problems and which requires an immediate solution plan and the issue of the collection and final disposal of solid waste in the city of Porto Velho. Silvera [17] makes another warning when it draws attention that the collection of waste is done in only part of the city's neighborhoods.

Paraguassu-Chaves (15), in Amazonian Studies of Medical Geography and Health, refers to the gaza strip in a given situation related to the environment of the urban periphery of the city of Porto Velho. This phrase would have already been used by Silveira (16), his graduate student in environmental analysis. Said Silveira (17) "Porto Velho looks more like a strip of gaza".

In Porto Velho the only area that has sewage services is the city center. The entire structure of the sanitary sewage service does not exceed 3%. Incipient to meet the demand of the population of Porto Velho. This record was made by Paraguassu-Chaves in the Amazonian Studies of Medical Geography and Health [15].

In the city of Porto Velho, the North Zone is the one that suffers the most from floods and overflow from the Amazon rainwater. Silva [2] confirms this by observing that streams and springs are transformed into open sewage This situation is observed in the neighborhoods that make up this Zone. Rodrigues [18], when

spatially assessing the quality of groundwater in the urban area of Porto Velho, has already warned about the contamination of water consumed by the human population.

Several studies endorse the scenarios found in the research. According to a study by Paraguassú-Chaves *et al* [19], urban groundwater used by the population for human consumption and other uses is impacted by high levels of N nitrate (NO3-). Seventy-three percent (73%) of the samples had contents> 10 mg / L of nitrate. These sites are urban areas of high environmental risk to human health, a public health issue. Only 7.5% of the samples are less than 3 mg / L nitrate. The high concentration of nitrate in urban groundwater in cities in the Brazilian Amazon puts at risk the health of a large part of the population that obtains this type of water resources for human consumption [20; 21]. The study "Nitrate Contamination of Ground Water: sources and potential health effects" by Bouchard, Willians, Surampalli [22], confirms this real situation and its effects on human health.

In a paper published in the "International Journal of Research and Science in Advanced Engineering", Paraguassú-Chaves *et al* [19] and another research result published in the journal "Debate in Action: scientific debate", Paraguassú-Chaves *et al* [23] demonstrate that urban groundwater in the city of Porto Velho, used for human consumption has a high concentration of nitrate. The precarious situation of sanitary sewage, distribution of drinking water of quality and quantity to serve the population, the collection and destination of solid waste found in this research is contrary to what is recommended by Brazilian legislation [24; 25; 26].

Among the conditions that aggravate the situation of water contamination by N nitrate (NO3-) in the urban area, is the inefficiency of basic sanitation (water supply and collection of sanitary sewage, construction of a rudimentary and septic tank in a precarious state). Queiroz, Heller, Silva [27], states that abundant and quality water is essential for public health, preventing diseases such as diarrhea and intestinal infections. These researchers analyzed the correlation between the occurrence of acute diarrheal disease and the quality of water for human consumption similar to those already found in Porto Velho.

Paraguassu-Chaves *et al* [28] highlights several health problems associated with non-standard nitrate and nitrite levels, which can promote diseases such as childhood cyanosis and, possibly, different types of cancer. The ineffectiveness of sewage services forces the local population to build black and septic tanks for the deposition of effluents in the vicinity of their homes that, in practice, contaminate groundwater. The proximity between water collection wells and human feces deposits has drastic consequences and a negative influence on people's quality of life [29].

According to IBGE [30], more than 40% of the Brazilian population use rudimentary cesspools or do not have any sanitation system and only 32%, that is, 61 million are correctly connected to the sewerage network. This procedure is manifested in the inadequate deposition of effluents, which are often discharged directly into the aquifer, as an alternative, in view of the low supply of sewage collection network in all municipalities of the State of Rondônia, whose percentage has 2% of service.

The water supply, whether public or private, may have its quality compromised by the lack of sanitary sewage in urban areas, where different substances are present, whether they are of natural or anthropogenic origin [31].

Other important studies corroborate the precarious situation of environmental conditions in the city of Porto Velho. Like Melo Junior *et al* [32] when he carried out an assessment of the quality of groundwater

in an urban area of the Brazilian Amazon: a case study of the Eletronorte neighborhood, Porto Velho - Rondônia.

Similar studies, such as Machado's [33], "Environmental quality: quantitative and perceptual indicators"; Wies, Silva [34] and Moret, Guerra [35] found results similar to those presented in this research. The environmental impact report of the Santo Antônio and Jirau plants already signaled the indicators of the environmental conditions in Porto Velho and the entire surroundings of the projects [36].

CAERD - Water and Sewage Company of Rondônia in its technical operational diagnosis of water supply and sewage systems - Basic Sanitation Program of the State of Rondônia, recognizes the lack of this essential service to the population of Porto Velho before and even after construction hydroelectric dams on the Madeira River.

This diagnosis corroborates the EBITA report from January to December of the years before and after the Jirau and Santo Antônio UHE's on the Madeira River in Porto Velho [37; 38].

It can be seen that Law No. 11.445 / 2007 and all legal amendments that establishes the national guidelines for basic sanitation in the case of Porto Velho is far from being complied with [39].

According to Barata [21], the number of households with access to the treated water network in most cities in the Amazon is still very low: only 16.88% of the households. While 83.91% are supplied by wells or springs on the property, only 4.84 wells or springs are located on properties. In the vast majority of Amazonian municipalities, there is no sewage collection network. Deficiency in basic sanitation can cause public health problems, because water pollution can cause diseases such as: basilar dysentery, dengue fever, yellow fever, leptospirosis, hepatitis A and others. The lack of basic sanitation in the city is compounded by the fact that most families are supplied by water wells with environmental risk. Therefore, a local culture of basically using open wells on its properties for human consumption is something extremely dangerous that requires further studies, such as the assessment of the socio-environmental impacts that affect this practice on human health [3].

According to Paraguassú-Chaves *et al* (3) another implication resulting from the lack of sanitation refers to environmental damage, such as floods, silting up of water courses (due to deforestation and monitoring of margins), disappearance of green areas, slopes of landslides, compromising water courses. water that turns into garbage dumps and sewage channels.

The concentration of public health units is found in neighborhoods called Embratel, Liberdade, Industrial, Nova Porto Velho, Conceição, Caladinho and Eletronorte. For Silva [2] in the distribution of health units there are large empty areas. As is the case with the situation in the East Zone according to Silva [2].

According to Silva [2] the concentration of medical services is high in the area that corresponds to Conceição, Caladinho and nearby neighborhoods, for example. When comparing the population density with that of the average number of low complexity patients, it is possible to verify that, although these neighborhoods have a high concentration, they do not present significant convergence of the population density. It is concluded, therefore, that the attendance to these health units includes the residents of this region and also the residents of the neighboring regions. In Porto Velho there are areas of the city that lack the concentration of medical care and health units.

According to Paraguassu-Chaves [40], the distribution of health units is at odds with the recommendations of the Ministry of Health of Brazil. For Paraguassu-Chaves [40], the spatial distribution of health units has

primarily obeyed political criteria and interests. For Paraguassu-Chaves [40], the decisions for the construction and operation of health units in the city of Porto Velho obey political criteria and interests and by determination of dominant groups in the local society.

Several studies are references to justify the research findings. Among them are the "Urban expansion of Porto Velho: analysis of the socio-spatial context of a city in transformation" by Almeida [41], "Conditions and quality of life in a reorganized space" by Azevedo [42], "The quality of life in the micro-region of Porto Velho, Rondônia: a quantitative study "by Cavalcante [43]," Systems of quality of life indicators "by Guillén-Salas [44], Porto Velho, the construction of the Madeira plants and the socio-environmental impacts of Gutierres, Marques [45], "The quality of life and its indicators" by Herculano [46], "Urbanization and quality of life in the municipalities of the Legal Amazon created after 1988" by Maniçoba [47], Pereira [48] "Geoprocessing of occupational diseases in Rondônia in the last decade", Pinheiros [49] "Social and institutional problems in the implementation of Hydroelectric Plants: selection of recent cases in Brazil and relevant cases in other countries", RIMA [36] "Report on the environmental impact of the Santo Antônio and Jirau plants", Seild, Zannon [50] "Quality of life and health: conceptual and methodological aspects", Paraguassú-Chaves *et al* [51] "Local Powe as the Basis of the Understanding of the Federative Pact", Uchôa, Uchôa [52] "Social inclusion in the region frontier ", Vieira Neto [53] "Culture, Leisure and Health. The generalized (dis) organization. A case study from Rondônia ".

Medical or health care services were the subject of research in Paraguassu-Chaves [54]. This author seeks to identify, from the perspective of health geography, a distribution and planning of infrastructure components and human resources of the health system.

In the analysis of Paraguassu-Chaves [54], public health services partially fulfilled their objectives throughout the historical process. This author analyzes the elements that make up the health system, based on some indicators. Among them, the author presents: human resources in health, training, professional experience, territorial and spatial distribution of professionals, attributions and legal competence; technological equipment and materials for dressings - real applications and needs; territorial and spatial distribution of health units; hospital beds in public and private institutions, among others.

According to Paraguassú-Chaves *et al* [3] the quality of medical care is provided for in the Brazilian Constitution: "everyone has the right to public health care, in a universal and equal way. This parameter is indicated as a negative aspect of quality of life. In addition, it is the duty of the State to provide access to health promotion, protection and recovery services".

However, although guaranteed in the Brazilian Constitution, there are some barriers in accessing outpatient and hospital services. Among these barriers, there is the unavailability of basic and specialized services for the majority of the population, in addition to the irregular geographic distribution of health units. Also according to the Ministry of Health, the limited distance between demand and supply, established an additional difficulty in the use of these services [3].

The Whoqol Group's quality of life assessment instrument [55] and the quality of life assessment model developed by Paraguassú-Chaves [56] can also be considered as the basis for supporting the research and its findings. The one that best represents the findings can be found in the book Epidemiological Profile of Rondônia by Paraguassú-Chaves *et al* [57].

As for the concept of quality of life, it suffers different interpretations, due to its area of interest. Frequently, concepts related to health concerns, personal satisfaction and happiness or conditions of service are adopted [58]. However, there are others who have a tendency towards lifestyle, conduct and behavior, health and human behavior, health and the environment, among others.

IV. CONCLUSIONS

The construction of hydroelectric dams in the Amazon draws more attention to the social and environmental problems involved than to the relative advantages that these projects bring to local society. At least that is what has been observed so far with the Health and Environment parameter.

All Zones in the phase that precedes UHE's Santo Antônio and Jirau on the Madeira River in Porto Velho, presented a performance of IQVU Regular. The values of the index classification scale decreased from the previous construction of the dams to the phase 1 year later and remains for 6 years afterwards.

The results pointed out by Silva (2) show that there was a decrease in IQVU from the phase prior to the UHEs to 1 year later. The South Zone was the most negatively impacted, moving from IQVU Regular to IQVU Bad.

The negative difference from the reference period before the hydroelectric plants to the reference period after the construction of the UHE's was IQVU of 0.088 and which corroborates with all findings over the last 6 years.

After 6 years, the quality of life indices IQVU in the Central Zone (0.456) Regular, IQVU in the East Zone (0.406), IQVU in the North Zone (0.428) and IQVU in the South Zone (0.393), with the average IQVU (0.420) of the city of Porto Velho. The difference between the average IQVU 6 years later in relation to the living conditions of the population in the period prior to the construction of the hydroelectric dams is -0.079.

What is observed is a worsening of the scenario of quality of life in the city of Porto Velho when evaluated by the parameters of Health and Environment. What was already the negative indicator after the hydroelectric plants became more negatively aggravated.

Porto Velho throughout its history has presented serious problems of infrastructure and inefficient public services. The installations of the UHE's that brought benefits to the population of Porto Velho ?. The results point much more to the negative aspects with the aggravation of the problems that already existed and the uncertainty of their solutions.

It can be said that there was a significant drop in IQVU in the city of Porto Velho. The IQVU, which already had a negative performance, worsened with the arrival of the Jirau and Santo Antonio UHE's on the Madeira River, in Porto Velho - Rondônia, Western Amazon.

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