Degrees of Risk of Environmental Impacts Arising from Irregular Occupations in the Northern Zone of Manaus - Amazonas

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Abstract

The disordered urban growth in the city of Manaus has had serious consequences for the environment in recent years, especially towards the northern part of the city. It is extremely important to verify the environmental impacts caused by this situation, in order to define the priority areas for planning and recovery actions of the areas. Sixteen areas were identified during the study, which were divided into four quadrants to define their risk levels. The risk levels were I - low, II - medium, III - high and IV - very high. The first criterion for dividing the areas in the quadrants was to identify similar characteristics between them and the second, the proximity of the areas, considering, therefore, the size of the area, as well as the loss of vegetation cover, the state of the soil and the existence and quality of the areas. water resources near the occupied areas. It was found that the presence of streams is a decisive factor to increase the environmental risk of a occupied area, in which anthropic actions intensify natural processes. Another factor considered is related to the degree of erosive processes, therefore, the occurrence of gullies and ravines accounted for the increased risk. After accounting for recorded impacts, quadrant B, located in the Cidade de Deus neighborhood, has a high environmental risk, while quadrants C and D have medium risk. These three quadrants have streams in their areas, however, quadrant A, which has no water body, has a low degree of risk, although three of its four areas have gullies. From this analysis, it is possible to define mitigation and impact containment measures, allowing natural resources to be preserved for the well-being of everyone today and for years to come.

Keywords: Urban growth; Risk areas; Environmental variables

1. Introduction

Manaus is considered a city with good rates of job opportunities, services, income and education compared to other municipalities in the state of Amazonas, presenting the best HDI in the state, generating great population attraction [1].

Population growth linked to the disorderly occupation rate over the years has generated a number of environmental problems, causing the urban area to grow in the countryside, replacing native vegetation with buildings and paving.

The city was not prepared to meet the population's demand for basic infrastructure such as sanitation and housing, increasing the population in peripheral areas [1].

Some of the most common problems triggered by this situation, inferring from numerous social, economic and environmental problems, are deficiencies in basic sanitation; lack of proper water and sewage treatment; and low frequency solid waste collection, factors that increase the likelihood that people living in these areas will suffer from the environmental impacts often caused by them [2]

In the last decades, the urban growth of the city has turned mainly to the north zone, being Cidade Nova, created in 1981, one of the first neighborhoods in this region through projects of construction of housing estates by the Government of the State of Amazonas, through of the Housing Superintendence - SUHAB [3].

After the creation of the first stage, others emerged as sets and neighborhoods, starting from the same. In 2010, the subdivision of the neighborhood, given by Municipal Law No. 1,401, of January 14, made the Nova Cidade, Cidade de Deus and Novo Aleixo neighborhoods official. Currently, these neighborhoods comprise 19.3% of the municipality's population, showing the importance of the region [4].

Among the neighborhoods mentioned, Cidade Nova and Cidade de Deus have, respectively, the Sumauma State Park and the Adolpho Ducke Forest Reserve, which are conservation units that are strongly affected by urban sprawl, a fact that can be viewed with the help of remote sensing tools. besides verified in person.

Using geotechnologies is an efficient way to locate areas without having to go on site, saving time and resources. In addition, environmental management, monitoring and inspection processes have used geoprocessing tools as a way to obtain data faster, more accurately and predict scenarios for decision making, as well as assist in solving social and environmental problems that directly affect the environment. welfare and safety of the population [5].

In addition to geotechnologies, it is important to use conventional methods where field truth is required, such as some forms of environmental impact assessment: Ad Hoc, Checklist, Interaction Matrix, Interaction Networks, Overlay Maps, Simulation Models [6]. To be more effective in studying areas, two or more methods need to complement each other, depending on the resources, time, and staff available.

In areas that are irregularly occupied close to urban buffer zones, such as forest fragments (which protect the soil) and also to watercourses, the Checklist is of great value in identifying the environmental impacts directly observed on the physical environment, vegetation cover. and water resources, thus identifying the degree of environmental risk in each location.

CONAMA Resolution No. 01/1986 [7], which deals with the basic criteria and general guidelines for environmental impact assessment, is that any change in the physical, chemical or biological properties of the environment caused by anthropic action is found. or natural, which affect the health, safety, well-being of the population; economic and social activities; the biota; the aesthetic and sanitary conditions of the environment; the quality of environmental resources.

Environmental impact is defined by the likelihood of the occurrence and the consequences caused, varying in its form, magnitude, location, specific characteristics and reversibility of the impact caused [8].

Therefore, the objective of the present study is to identify the environmental impacts intensified by anthropic actions in the Cidade de Deus and Cidade Nova neighborhoods, with the purpose of dividing the areas into quadrants and defining their risk levels directly affected by urban growth and occupations. irregular in the last ten years. The risk degrees of the impacts caused by this situation will be compared at grade I (low), II (moderate), III (medium) and IV (high).

2. Materials and Method

2.1 Study area

In the urban area of Manaus / AM (-03º 01 '47.73 ”S and -59º 58' 07.19” O), the study areas, located in Cidade Nova and Cidade de Deus neighborhoods, have irregular occupation. over the last ten years and generate environmental impact on areas considered at risk. The coordinates of the analyzed areas, located via Google Earth and transformed to decimal coordinates, are recorded in table 01.

Table 01. Decimal coordinates of the evaluated areas.

AREA	LAT	LONG	AREA	LAT	LONG	AREA	LAT	LONG	AREA	LAT	LONG
01	-3,0176	-59,9597	**05**	-3,0099	-59,9516	**09**	-3,0274	-59,9557	**13**	-3,0225	-59,9698
02	-3,0126	-59,9619	**06**	-3,0095	-59,9516	**10**	-3,0125	-59,9686	**14**	-3,0247	-59,9654
03	-3,0106	-59,9565	**07**	-3,0222	-59,9507	**11**	-3,0159	-59,9672	**15**	-3,0437	-59,9777
04	-3,0104	-59,9557	**08**	-3,0303	-59,9506	**12**	-3,0210	-59,9641	**16**	-3,0451	-59,9830

Source: Own authorship (2019).

2.2 Data Collection

The research is characterized as descriptive-qualitative, being raised in the field in order to verify the set of situations of the areas covered in this study. Along with this process, the causes and consequences of environmental impacts were discussed. The tools used to obtain the data were Google Earth Pro; ArcGIS 10.4; Microsoft Excel 2013 and the Checklist method for environmental impact assessment, in which the collected data were determinant for the characterization and classification of the degrees of risk and type of impact on the environment.

Google Earth Pro has been used to identify areas of irregular occupation that have emerged over the past ten years, targeting those with remnants of vegetation, water bodies and steep slopes in their vicinity. Geographic coordinates were collected using this software and later added to a Microsoft Excel 2013 spreadsheet to convert them to decimal coordinates. After the insertion of decimal coordinates of the areas in the Excel table, the work of creating shapefiles in ArcGIS 10.4 began.

Subsequently, the area was divided into four quadrants in ArcGIS 10.3 and the number of four areas in each was accounted for. From this, there was a field survey, in which each area was visited and the components found from the environmental impact analysis method through the checklist were observed, which used to identify and enumerate the environmental impacts, and with bibliographic basis, the risk levels of the quadrants in the neighborhood area were defined.

It was verified the existence of irregular occupations and the impact on the soil caused by natural actions intensified by the anthropic. The process also used the ArcGIS and Google Earth tools to measure irregularly occupied land, which is fundamental to stipulate the price of land, multiplying by the value of the m², thus defining how much the government responsible for land has lost economically in recent years.

2.3 Criteria for establishing risk grades

The first criterion established depended on the slope and the distance where the occupied areas are positioned. The areas, when visited, had the slope estimated macroscopically and images were recorded to prove it. The length was defined using the Google Earth geoprocessing tool.

It is known that the population itself creates new risks beyond the occupation and suppression of the vegetal area, such as effluent discharge in irregular places, solid waste, among those that were identified during the on-site visit. The model described in Table 02 was used as a basis to identify the environmental impacts encountered at the sites during field visits.

Table 02. Model for establishing risk factors in study area visits.

CHARACTERISTICS TO BE ANALYZED					
GROUND	Occurrence of steep incline (above 45 °)	Furrow (do not consider) Ravine (YES) Gully (YES)	Receiving inappropriate waste disposal	Receiving effluent discharge	
WATER RESOURCES	existence	Occupation distance in disagreement with Brazilian Forest Code	Waste in the watercourse	Silting Process	Eutrophication Process
VEGETAL COVER	Dimension of total area (above 5,000 m²)	Size of occupied area in m² (consider risk if more than 20% of lost area)			

Source: Own authorship, 2019.

A table was created to account for impacts in each quadrant. Therefore, each item per area could be worth up to four. Then, from the sum of the impacts, divided by the number of areas, it was possible to establish the degree of risk for each of them.

During the visits to the areas, it was reported which of the factors, together, occur in each one, thus defining the ones that suffer the greatest environmental impacts. Finally, each area was allocated to a quadrant next to the nearest areas, observing the risk levels of the occupied areas, being degrees I - low, II - medium, III - high and IV - very high.

Among the eleven components described in Table 02, the risk will be defined based on the number of the following aspects.

- Low risk (grade I): one to three aspects;
- Medium risk (grade II): four to six aspects;
- High risk (grade III): seven to eight aspects, and;
- Very high risk (grade IV): from nine to eleven aspects.

3. Results and discussion

The change in land use and occupation in the last ten years (2009-2019) in the study area is highly significant, where vegetation suppression was the aspect that suffered the most loss, an aspect analyzed through remote sensing. This is a worrying factor economically because the minimum price of these areas is high wherever it is located. The m^2 numbers of the areas are described in table 03.

Table 03: Lost values and areas in m^2 for irregular occupations.

	Lost Values and Areas (m^2) for Irregular Occupations					**Lost Values and Areas (m^2) for Irregular Occupations**			
			Cidade Nova	Cidade de Deus				Cidade Nova	Cidade de Deus
	Size of the area (m^2)	Occupied zone	R$ 185,57	R$ 40,17		Size of the area (m^2)	Occupied zone	R$ 185,57	R$ 40,17
Area 01	**266.302**	**115.916**	**21.510.532,12**	-	**Area 09**	**36.398**	**2.263**	-	**90.904,71**
Area 02	**46.159**	**15.078**	-	**605.683,26**	**Area 10**	**9.907,28**	**11.103**	**1.838.493,95**	-
Area 03	**152,62**	*	-	**6.130,74**	**Area 11**	**45.134**	**1.775**	**329.386,75**	-
Area 04	**68,94**	*	-	**2.769,32**	**Area 12**	**28.810**	**10.125**	**1.878.896,25**	-
Area 05	**750,13**	*	-	**30.132,72**	**Area 13**	**46.577**	**19.659**	**3.248.120,63**	-
Area 06	**659,45**	**	-	**	**Area 14**	**24.331**	**9.532**	**1.768.853,24**	-
Area 07	**14.217**	**1.543**	-	**61.982,31**	**Area 15**	**181.953**	***	-	-
Area 08	**8.818**	**2.476**	-	**99.460,92**	**Area 16**	**55.296**	**4.399*** **	**816.322,43**	-

Source: Own authorship, 2019.

* areas that do not have direct occupation over the site, ** area belonging to the union and with priceless rich biological and natural heritage; minimum value simulated because the area is rich in biodiversity.

All areas of this study have their uniqueness, with some features also found elsewhere. However, four strongly draw attention because it contemplates most of the aspects analyzed in the places, being them in red color (figure 01).

Figure 01: Areas analyzed.
Source: Own authorship (2019).

The quadrants, called A, B, C and D, have four areas each, encompassing similar aspects between them, which is the first criterion for subdivisions. The second criterion is the proximity between the areas. From the extent of loss of vegetation cover in the last ten years, described in table 4, it is possible to delimit the environmental impacts and risks of each quadrant.

Table 4: 2009-2019 loss of vegetation cover in the study area.

Quadrant	Quadrant Areas	Neighborhood	Neighborhood Area (m²)	Occupied zone (Last 10 years)	% loss of vegetation cover
A	3, 4, 5 e 6	Cidade de Deus	1631,14	no significant n°	0
B	2, 7, 8 e 09	Cidade de Deus	96.774	21.360	22,1
C	01, 10, 11, 13	Cidade Nova	367.920	148.453	40,3
D	12, 14, 15, 16	Cidade Nova	206.284	24.056	11,7

Source: Own authorship, 2019.

The loss of vegetation cover in quadrant C is the most significant, where 40.3% of the total area was lost to irregular occupations. There is a tendency of demographic growth in the area, where it is worrying about the preservation of the main area with remaining vegetation in the same quadrant, area 11. This one, which has steep declivity, houses a significant biodiversity, such as Sauim de coleira, an endemic and highly endangered species.

Quadrant B covers the smallest amount of occupied area in the last years, being possible to notice that the occupation does not tend to increase high, being a limited area; while quadrant A does not have significant occupancy numbers given the short perimeter compared to other areas, however, the impacts on them are of significant importance.

Quadrant D has two areas located near strategic points, such as Av. Gov. José Lindoso, access road to the south-central area. The fact that these areas are located near housing estates not derived from the famous "invasions" and with greater supervision over the sites, may interfere with not being greatly impacted.

In contrast, the remaining two areas of the quadrant - 12 and 14 - have a higher rate of irregular occupations, totaling 19,657 m², or 81.7% of the total area occupied in the quadrant. The possibility of areas located in the peripheral zone being more prone to the appearance of irregular occupations was observed during this analysis, except for areas without more space for expansion.

Loss of vegetation cover is the primary aspect for the emergence of several other impacts, such as erosion, particle carry-over to water bodies, construction of irregular occupations that generate effluent discharge, often without basic treatment, in inappropriate places, such as soil and watercourses, as well as loss of biodiversity at the sites.

Therefore, it is important to cite the impacts caused by the situation, starting from the ground, as described in table 5, in order to define the degrees of risk of the quadrants.

Table 05: Impacts on soil by quadrant.

	Area	Approximate Tilt Angle	Erosion type	Occurrence of waste dumping	Occurrence of effluent discharge
Quadrant A	3	80°	Gullet	Not included	X
	4	80°	Gullet	X	X
	5	80°	Gullet	X	X
	6	25°	Not included	X	Not included
Quadrant B	2	12°	Groove	X	X
	7	25°	Ravine	X	X
	8	12°	Not included	X	X
	9	55°	Not included	Not included	X
Quadrant C	1	80°	Gullet	X	X
	10	65°	Gullet	Not included	X
	11	52,5°	Not included	X	X
	13	35°	Groove	Not included	X
Quadrant D	12	23°	Groove	Not included	X
	14	40°	Ravine	X	X
	15	30°	Groove	X	Not included
	16	40°	Not included	X	X

Source: Own authorship, 2019.

From the data analyzed, it is observed in quadrant 01, the occurrence of high slope relief and gullies identified in 75% of the areas. In them, where the dystrophic yellow latosol was located, the effluent from the houses near the top, directly above the ground, was also observed.

In the areas 04 and 05 of the referred quadrant, it was possible to notice that effluent discharge occurs directly on the soil, resulting in the vegetation growth (figures 03 and 04). At the same time, in area 06 -

edge of the Adolpho Ducke reserve - there is the occurrence of an addicted dumpster, in which the odor and occurrence of vector proliferation are high. Waste was carried to the base of the vegetation after torrential rain.

Figure 02: Area 03

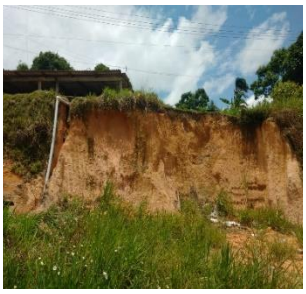


Figure 03: Area 04

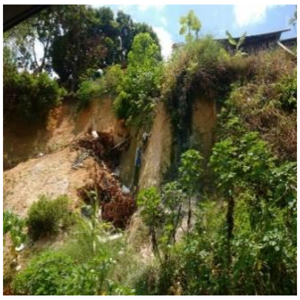


Figure 04: Area 05

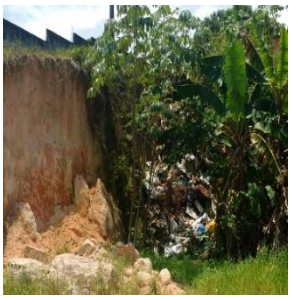


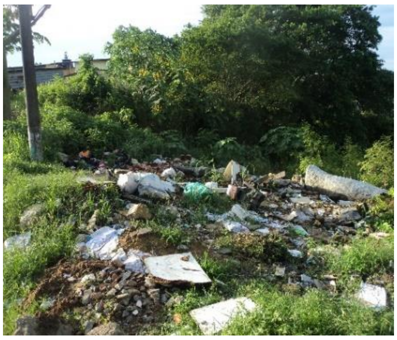
Figure 05: Area 06.

Source: Own authorship, 2019.

The region's soil situation is of concern, as erosion is in a difficult phase to contain. There are few areas in the early-middle phase of increasing erosion dimensions, such as furrows and ravines, which can still be contained.

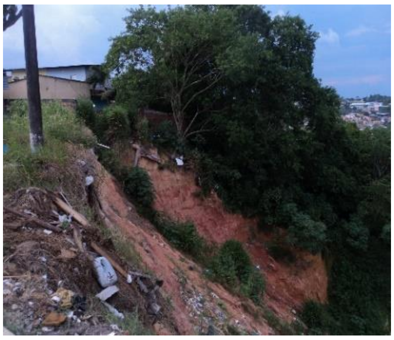
Quadrant C, which has the second highest rate of gullet occurrences, differs from quadrant A because it has a total of occupied areas 7 times larger. In addition, it has the highest land use index in the last ten years, in which 40.35% of the vegetation cover has been lost. Allied to factors that occur after occupation, such as improper dumping of solid waste and effluents, this aspect promotes an increase in the percentage of soil losses, favorable to the increase of the size of erosion areas, as in area 01 (figures 06 and 07).

Figure 06: situation of area 01 (quadrant C) in 2017.



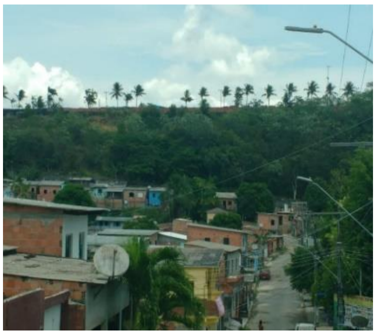
Source: Own Author

Figure 07: situation of area 01 (quadrant C) in 2019.



Source: Own Author

Figure 08: Area 09, Quadrant B



Source: Own Author

It is important to emphasize that the areas of quadrants A and C are close, making it possible to state that the coverage area of both quadrants has the most marked relief of the study. Therefore, the area tends to the appearance of erosions that, if not contained, evolve to larger dimensions, reaching the gully level.

As for the erosion ratio in the soil, quadrant D does not stand out, since it has a vegetation cover, still conserved in the last ten years; Areas 12 and 14 have lost a significant number of vegetation cover, however, their relief is not greatly accentuated.

In quadrant B, which has only one area without vegetation cover and ravine type erosion, it was possible to observe an area unique to the others in this work. It was observed the occupation of the base of a steep slope, of approximately 55 °. The area, which is the division of a collective garage and the Cidade de Deus neighborhood, has native vegetation - sustaining the slope - at the same time as the occupation, also receives effluent discharge without any treatment, resulting in destabilization of the slope. (figure 08).

Impacts on the ground are easily observed in the occurrence of irregular occupations, because of this, they are the first to be noticed. Another type of worrying impact is on water resources. In this case, in urban areas. Among the 16 study areas, 07 areas with impacts on the watercourses were analyzed, as detailed in table 6.

Table 06: Situation of streams observed in the study areas.

Quadrant	Area	Existence of watercourse	Approximate Width	Occupation distance shorter than recommended	Waste in the stream	In the process of silting	In process of eutrophication	Untreated effluent discharge
A	3	-	-	-	-	-	-	-
	4	-	-	-	-	-	-	-
	5	-	-	-	-	-	-	-
	6	-	-	-	-	-	-	-
B	2	X	5 m	X	X	X	X	X
	7	X	3 m	X	X	X	X	X
	8	X	5 m	X	X	X	X	X
	9	-	-	-	-	-	-	-
C	1	X	7 m	X	X	X	X	X
	10	-	-	-	-	-	-	-
	11	-	-	-	-	-	-	-
	13	-	-	-	-	-	-	-
D	12	-	-	-	-	-	-	-
	14	-	-	-	-	-	-	-
	15	X	9 m	Not included	X	X	Not included	Not included
	16	X	5 m	Not included	X	X	Not included	Not included

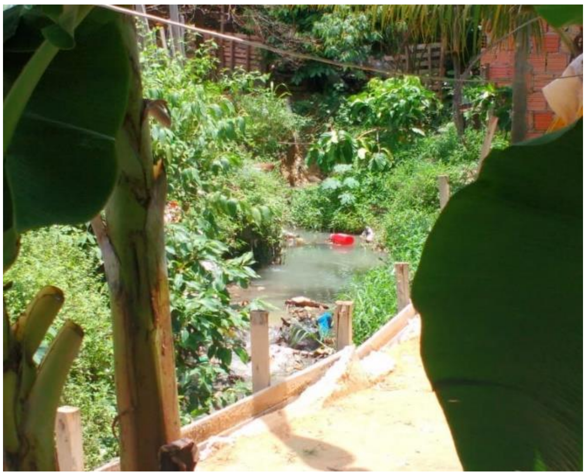
Source: Own authorship, 2019.

In relation to watercourses, it was observed that in quadrant B the impacts on streams are the most significant, where they are at serious risk of not being able to resist anthropic actions if they continue to receive the current level of impacts. about them. One of the factors that warns of the resistance of streams over the years is the width of the streams, because all, in the dry season, reach less than 10 m wide.

In this quadrant, which is the most worrisome, there is also the loss of vegetation cover on the banks of water bodies for the occupation of simple and many precarious dwellings, which are flooded during torrential rain, which impairs the natural water cycle. As reported in table 03, the watercourses analyzed in quadrants B and C are silenced due to loss of vegetation cover, and it is possible to locate solid waste and tailings (figure 09), as well as the discharge of untreated effluents. due basic treatments, causing the eutrophication of water bodies near inhabited areas.

Figure 09: Area 01 stream margin situation (quadrant C)

Figure 10: Excerpt from area 07 stream (quadrant B)



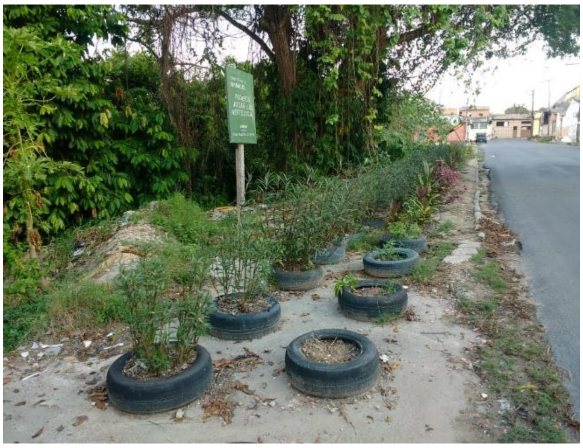
Source: Own authorship, 2019.

During the visits to the analyzed areas, solutions were also found for the areas. Area 11, located in quadrant 03, received a large volume of tailings and solid waste, mainly from civil construction and furniture used until early 2019 (Figure 09). In mid-June of that year, the City Hall installed prohibition signs regarding the disposal of these materials on the area, which has a high conservation index of the vegetation that protects the soil from exposure and possible erosion, as it has rugged relief. .

In addition to the plaques, ornamental plants were inserted in the area as a measure of sensitization to the residents of the region (figure 12) so that there is no disposal of tailings in this area.

Figure 11: Area 12, in 2017;

Figure 12: Area 12, after City Hall Action

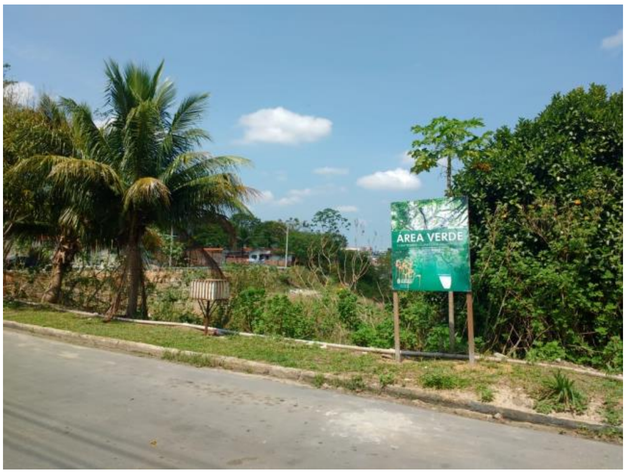


Source: Own authorship, 2019.

Another example of recovery attempt was found in area 14, located in quadrant D, where ravine-type erosion that served as an open-air dumpster occurs. As in area 12, waste disposal boards and tire-wrapped ornamental plants were installed (figure 13). However, the area also received the Green Area sign (Figure

14).

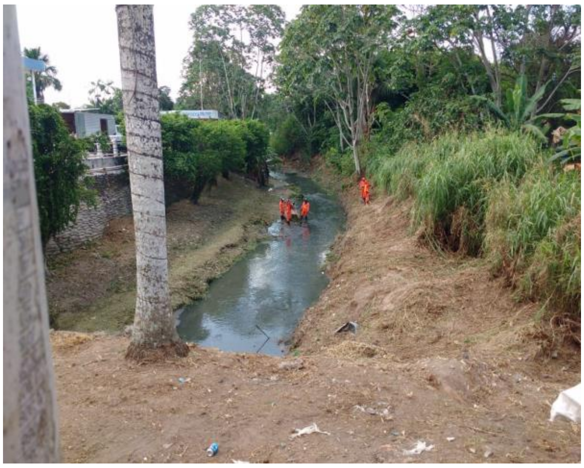
Figure 13: Area 12 (Quadrant D) Recovered. **Figure 14:** Green area code in area 12.

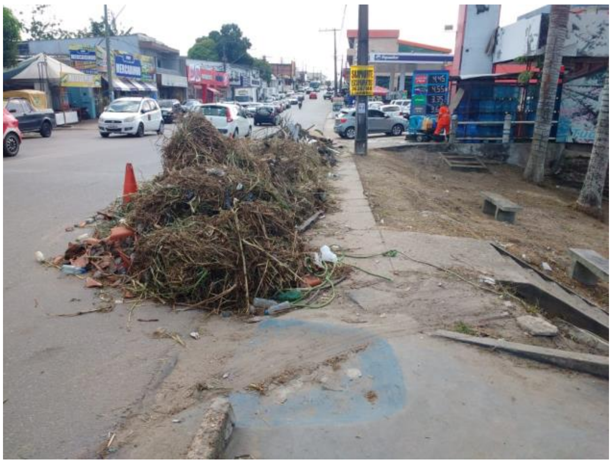


Source: Own authorship, 2019.

Differently from the areas described above, both previously receiving solid waste, recovered by awareness actions of the city hall, in area 15, there was a work of cleaning the local stream (Figures 15 and 16). The action improved the flow velocity of the stream, removing the vegetation that covered it and the solid waste suspended or trapped in the vegetation.

Figure 15: Stream cleaning action in area 15 (quadrant D). **Figure 16:** Amount of vegetation and waste removed from site.





Source: Own authorship, 2019.

Degrees of risk

After analysis of the events occurring on areas of the quadrants and in accordance with the observed facts, the result of the analysis of the degree of risk is given as follows:

Table 7: degrees of risk in the quadrants.

	A	B	C	D
Area Dimensions	-	4	4	4
(above 5000 m²)	-	1	2	2
Area occupied (> 20%)	3	2	3	-
Tilt (> 45 °)	3	1	2	1
Erosion (Ravine / Gully)	3	3	2	3
Soil residues	3	4	4	3
Effluents on soil	-	3	1	2
Existence of a stream	-	3	1	-
Creek Distance-Occupied Area	-	3	1	2
Residues on the stream	-	3	1	2
Siltation in the stream	-	3	1	-
Effluent discharge directly into the stream	-	3	1	-
Eutrophic Igarapé	12	32	23	19
		DIVIDE BY 4		
	3	8	6	4,75

Source: Own authorship, 2019.

Through the sum of the impacts intensified by anthropic actions and the subsequent division of the numbers by the number of areas, the quadrant identified as the one that suffers the greatest environmental impacts was the B, located in the Cidade de Deus neighborhood, with high risk, having 8 aspects around all. The factor that most contributed to the result was the number of streams by area and their states, all in degeneration and close to occupations.

Quadrant A, which does not have water bodies, has the lowest risk compared to the others, reaching an average of 3 impacts, mostly related to erosions. Meanwhile, the C and D quadrants, with respectively 4.75 6, and the results were included in the average degree of risk.

Quadrant A, which has areas with more similar characteristics, showed greater homogeneity during the descriptions of environmental impacts by irregular occupations. Meanwhile, areas with significant differences in characteristics found in others in the quadrant changed the risk level of the quadrant, such as area 01, inserted in quadrant C. If the risk grades were accounted for by area, the risk degree of the area 01 would be given as 'very high', but as the other areas analyzed in the quadrant have less impacts intensified by anthropic actions, resulting in a lower degree of risk, the average of the points evaluated in the quadrants generated an average risk.

Therefore, it is possible to affirm that areas with homogeneity of characteristics result in a more accurate quadrant risk degree, in contrast to quadrants that have areas with different characteristics, resulting in a different risk degree to the reality of the areas.

4. Discussion

The effects of unbridled growth, which have been highly impacting, in recent years are directed to the northern area of Manaus, where there are still several areas with vegetation cover, seen by the occupation agents as an area to explore. Often, housing in precarious and unhealthy conditions is occupied close to the streams, emphasizing how problematic territorial management, the organization of a single planning pattern and the ordering of a metropolis such as Manaus [9].

As spaces and the natural environment are transformed by anthropic actions, there is the destruction of springs, threats to the extinction of native animal species, erosion problems, flooding and loss of vegetation cover [10].

Many of the areas covered in this study, located in occupations near watercourses and steep slopes, are considered Permanent Preservation Areas - APP [11]. This law establishes the protection of marginal areas of watercourses up to 10m wide by 30 meters of riparian forest and native vegetation on each side, in addition to considering APP slopes and part of them with slopes greater than 45 °. However, the law is not being respected, as irregular occupation was found in a shorter distance than recommended, the removal of vegetation on slopes and the non-preservation of these, where also the dumping of solid waste in inappropriate places.

The factors found in the present study resemble those found by [12] in the Gilberto Mestrinho neighborhood, such as irregular occupation of slopes, siltation of canals, suppression of vegetation cover, cuts in slope profile for terracing, housing and land use. , waste disposal, poor sanitation infrastructure.

The loss of the vegetation cover of the space promotes the forest fragmentation of areas with less interest for the occupation, resulting in the isolation of species, placed in a fragile situation. The distance between fragments influences the lack of interactivity with their continuous habitat, which is detrimental to plant and animal populations with continually migrating migration and dispersal rates [13].

According to [13], one of the most common impacts on edge effects of a forest fragment occurs from the contact of two different environments, in which one suffers alteration under the influence of the other. This situation, found in area 06 (quadrant A) and areas 01 and 11 (quadrant C), reflects the impact caused by the population on forest fragments and gullies edges, which receive a large amount of solid waste, visually impacting besides providing proliferation of pathogenic vectors.

Anthropic impacts on forest fragments also occurred in the studies of [14], in which the release of fresh sewage into the woods and inadequate disposal of waste was observed. Similar to the present study, several disturbances threaten the fragile balance of the ecosystem, all related to human activities on the local environment.

The study of [15], which also identified solid waste dumping in forest edge areas and water bodies, enabled the development and attraction of pathogenic vectors, as well as obstructing galleries and decreasing oxygen in the waters, which was can be found in area 16, located in quadrant D of this study.

At the same time, the commitment not allied to non-awareness of the environmental damage is one of the main factors for the incidence of solid waste in streams. Many people not only throw directly on the watercourse, but accumulate the waste in improper places, the so-called junk dumps, which during heavy rains, are carried by water to the streams [16]. In addition to wastewater in streams, Manaus water bodies also receive 89.82% of freshwater sewage discharged directly into their beds, as stated by [17].

The development of urbanization most often not only negatively impacts water bodies and vegetation cover, but also influences the development and acceleration of erosion processes, which slows down when urbanization is consolidated and receives the intervention of the government. It is stated that in many areas, the main cause of gullies is human intervention, given the ineffectiveness of government supervision to prevent urban occupation [18]. The instability of slopes, unique among the areas, is potentiated through anthropic interventions, such as vegetation suppression, cuts, landfill, garbage disposal, risk factors that can lead to fatalities [14].

Along the eastern zone, the northern zone of Manaus has the largest amount of erosive processes in the city, in which there is the presence of high slopes, where there are several housing estates in the flat areas of the board tops, reaching the edges of the erosive areas. Erosions arise naturally or accentuated by anthropic actions. The most severe forms of erosion are ravines, which if not contained in time, evolve into gullies, both derived from the action of runoff, but gullies present a higher risk due to complexity and potential linear erosion [19].

The identification of environmental risks is preceded by something primarily impactful. Risks have different effects that a given event may cause, at one point or that may be forwarded to another [13].

Urban risks, mainly due to climate actions, such as excessive rainfall and unorganized occupations, such as streams and slopes, bring the need to establish preventive measures and mitigate environmental impacts [20].

5. Conclusion

Field studies combined with the Checklist tool and the use of geoprocessing tools to perform comparisons on vegetation loss have shown that the influence of urban growth on natural area remnants such as forest fragments, water bodies and their impacts is highly worrying.

All water bodies - an essential factor for the degree of risk - are in a siltation state, as well as most receiving solid waste disposal. Quadrant B, which has in three of its four areas waterways, has the highest degree of risk. Meanwhile, areas with gullies and gullies were also highlighted during impact accounting. Quadrant A, which has three gullies - the most advanced erosion state - with steep declivity, has a low environmental risk, with an average of three impacts, due to the size of its areas, as well as the lack of water resources.

The quadrants located in the Cidade Nova neighborhood, C and D, have medium risk degrees, with great variation because their areas do not have a homogeneity of the components found in the evaluation. It can be said that if the areas were evaluated individually, some of them could fall into the high risk category. The heterogeneity of environmental characteristics had a strong influence on the quadrant as a whole. Explained by homogeneity, an essential factor in the search for results closer to the reality of the places.

During the on-site visits, it was possible to observe the intervention of the city hall in the recovery of three areas, all in the Cidade Nova neighborhood, two with steep slopes, raising awareness about the reduction of solid waste disposal on their edges. The third area is the stream 15, where the cleaning occurred for better water circulation, in which excess vegetation over the stream and accumulated solid waste was removed.

The actions of the city in relation to the environment are of great value for the promotion of the well-being and sensitization of the population of the area to choose to do the right and maintain the conserved areas. However, similar work is required in all areas. The difficulty is known, but if the actions were repeated in many other areas, we would not possibly be able to see how quickly degradation reaches all natural environments still trying to exist in our urban area.

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