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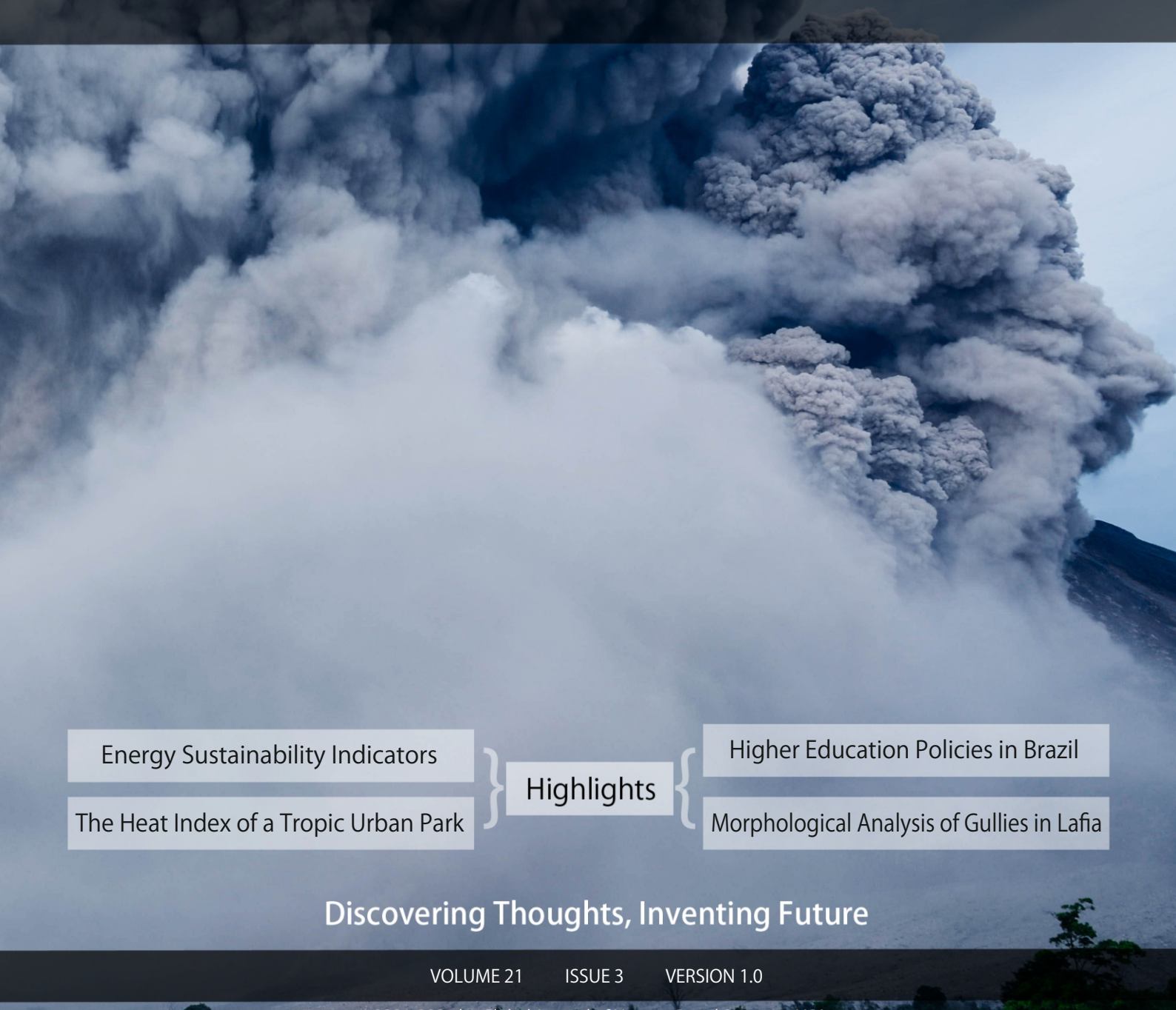

Energy Sustainability Indicators

The Heat Index of a Tropic Urban Park

Highlights

Higher Education Policies in Brazil

Morphological Analysis of Gullies in Lafia

Discovering Thoughts, Inventing Future

VOLUME 21 ISSUE 3 VERSION 1.0

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Public Energy Management and Decision- Making Model: A Proposal based on Energy Sustainability Indicators

By Fabricio Quadros Borges, Fabrini Quadros Borges & Mario Rocha de Vasconcelos
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Abstract- The objective of this study is to develop a decision-making model for the Brazilian electricity sector, based on sectoral indicators of energy sustainability. The methodology of this investigation constructed sectorial indicators of energy sustainability, from linear correlations verified between variables of the energy input and development variables, whose results fed a decision-making structure supported by technology, norms and rules and in the decision style. The place of study was the State of Pará and the time span between 2010 and 2019. The investigation concluded the need to re-read the decision-making process in the Brazilian electricity sector, through the essential use of a sectorial system of indicators, which demonstrates strategic respect for the specificities the economic sectors and to guide, through a decision-making model, how electricity can be translated into development based on the productive processes of these sectors.

Keywords: *electric energy. investments. economic sectors.*

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Public Energy Management and Decision-Making Model: A Proposal based on Energy Sustainability Indicators

Fabricio Quadros Borges [α], Fabrini Quadros Borges [σ] & Mario Rocha de Vasconcelos [ρ]

Abstract- The objective of this study is to develop a decision-making model for the Brazilian electricity sector, based on sectoral indicators of energy sustainability. The methodology of this investigation constructed sectorial indicators of energy sustainability, from linear correlations verified between variables of the energy input and development variables, whose results fed a decision-making structure supported by technology, norms and rules and in the decision style. The place of study was the State of Pará and the time span between 2010 and 2019. The investigation concluded the need to re-read the decision-making process in the Brazilian electricity sector, through the essential use of a sectorial system of indicators, which demonstrates strategic respect for the specificities the economic sectors and to guide, through a decision-making model, how electricity can be translated into development based on the productive processes of these sectors. This study, which presents a suggestion for this system of indicators and can be applied to any Brazilian state, points out that public actions in Pará should promote an increase in energy autonomy, redirection of the industrial profile, inclusion of compensatory devices for environmental costs and targeting from strategic investments to the increase of Gross Intensive Product.

Keywords: electric energy. investments. economic sectors.

I. Introduction

Electricity public management and decision-making aspects in the electricity sector have always been prominent in the social debate. Modern society uses increasing amounts of electricity (Narayan, Doytch, 2017). Electric energy has always been a fundamental bias in the development process of societies (Collaco et al., 2019). According to Schultz (2016) and Pereira (2018), public management encompasses intricacies linked to the territory and the needs of populations, in order to also involve connections between economic, social and political powers, through decision-making.

The electricity sector is a social organization formed by systemic relationships that involve the process of transforming primary energy to its finais use by type of consumer. These relationships are established between the components of the electricity sector, such as: generation, transmission and distribution of electricity. Electric energy is a secondary energy that can be acquired through primary energy sources transformed from converters; however, depending on the nature of these converters, the generation of electricity can direct economic, social, technological and environmental impacts, to a greater or lesser extent, from all sectors of economic activity (Reis, Fadigas, Carvalho, 2012). The quantitative and qualitative profile of the availability of the energy input establishes bases for the conditions of the populations to guarantee a certain quality of life through. It is in this sense that the construction of electricity sustainability indicators represents relevant tools in view of the possibility of unraveling the existing intricacies between electricity and quality of life.

According to Borges (2012), in public electricity management, indicators favor the decision-making process through guidelines, which tend to articulate with greater precision the strategic mission of energy with the development of regions and countries. In each economic segment, electricity reflects in order to generate jobs, levels of income concentration, consumption flow, volumes of polluting gases emitted, from different quantities. (Amaral, 2017). In this perspective, this study asks: how could decision-making in the electricity sector in Brazil be supported by sectorial indicators of energy sustainability? The purpose of this investigation is to build a decision model for the electric energy sector in the country, supported by sectorial indicators of electric energy sustainability.

II. Theoretical Framework

The discussion environment about public management has raised numerous relevant aspects for examining the capacity of public managers to achieve efficient goals in dealing with public resources invested in regions or countries; among these aspects, it is cited the interference of the ideological field of people who influence more decisively with the decision-making power, through relations in segments, such as electricity among them, the influence of ideologies of groups that interfere with more power of decision, through correlations of forces along various branches, such as energy (Schultz, 2016).

The public energy management environment is developed through public policies in the electricity

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sector, which generally aim to demonstrate that investments aim at economic growth and improving the population's living conditions. In this process, strategic aspects are verified, from the choice of electricity generation sources to the effects of the use of this energy in the different sectors of a country's economy (Bermann, 2003; Borges 2012; Cornescu, Adam, 2014).

As for decision-making in the public environment, according to Silva (2013), there are three elements that make up a decision-making process within public management. They are: technology; rules and norms; and decision-making style. With regard to technology, it is observed that the administrative and organizational structure must be improved from instruments relevant to information technology to support decision-making, as a way of reducing risks, that is, without using aspects of a subjective nature; as for the rules and norms, it is highlighted that the obedience to these norms and rules makes it possible to achieve optimization in decision making; and finally, with regard to the decision-making style, it is highlighted that it refers to the common standards that decision makers tend to use when facing a decision-making panorama (Silva, 2013).

In this perspective of discussion, attention is drawn to the mission of electricity sustainability indicators in line with the intricacies of the decision-making process. Indicators must be interpreted based on the definition of sustainable development. Sustainable development seeks sustainability and the difficulties in conceptualizing the terminology sustainability demonstrates the difficult task of reflecting concepts in practical terms (Sachs, 2009; Costa, Teodósio, 2011; Prado, 2015). According to Costa and Teodósio (2011), sustainability comprises the ability to maintain bases of an economic, social and environmental nature that generate the possibility of contemplating the demands of populations in a harmonious way and the organized possibility of examining sustainability is in line with the elaboration of sustainability indicators.

The effort to improve energy analysis tools along with the development process has translated since the 1990s into three important contributions. The indicators from Helio Internacional, the indicators from the National Electric Energy Agency - Aneel and the indicators from Camargo et al. (2004). The indicators of Helio International (2005) are composed of eight indicators, divided into four aspects: economic, environmental, social and technological. The indicators from Aneel (1999) punctuated the ecological, political, economic and technological aspects. And finally, the indicators by Camargo et al. (2004) were composed in economic, environmental and social indicators.

III. Methodological Strategy

The study site was the State of Pará. Pará comprises a geographical area of 1,247,689.515 km² and an estimated population of 8,690,745 inhabitants, which gives it a density of 6.96 inhabitants/km² (Ibge, 2020). The public electricity distribution service in the State is a concession of Centrais Elétricas do Pará - Celpa, while the share in the generation market is the domain of Centrais Elétricas do Norte - Eletronorte.

The correlation sought as a result a coefficient that quantified the degree of correlation *Pearson's coefficient (p) (Chen, Popovic, 2002).*

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2} \cdot \sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}},$$

Where: x1, x2, ..., xn and y1, y2, ..., yn comprise the measured values of both variables. And the following equations are the arithmetic means of these variables:

$$\bar{x} = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i \quad \text{e} \quad \bar{y} = \frac{1}{n} \cdot \sum_{i=1}^{n} y_i$$

The linear correlations verified in each dimension, through the sectors, were described and analyzed regarding their importance, representativeness and used measurement unit. Later, the variables were organized according to the dimensions: economic, social, environmental and political, which built the energy sustainability indicators, and from each sector of activity, which made up the energy sustainability indices. In calculating the indicators, we proceeded from a weighted average composed of the result of the calculation of the composite variables. In calculating the composite variables, the calculation adopted two variables: the first referring to development, and the other referring to the energy environment.

Table 1 shows the construction structure of the index and the electricity sustainability indicators for the agricultural sector in Pará.

Table 1: Structure of construction of electricity sustainability indicators in the agricultural sector of Pará, Brazil.

Índex = E + S + E + P / 4	INDICATOR	AGRICULTURAL SECTOR ECONOMIC INDICATOR VARIABLE	COMPOSITION	RANGE	LEVEL
	Economic (E) Indicator=1+2+3 / 3	GDP/Quantity of KW consumed	In addition to R$ 120	4	High
			From R$ 120,00 to R$ 106,00	3	Good
			From R$ 105,00 to R$ 91,00	2	Medium
			Until R$ 90,00	1	Low
		Quantity of GW consumed /amount invested in electricity	In additionto0,75 GW	4	High
			From0,75 to 0,51GW	3	Good
			From0,50 to 0,26 GW	2	Medium
			Until0,25 GW	1	Low
		Variation in electricity tariff /amount invested in electricity	In addition to 0,20 %	4	High
			From0,20 % to 0,16 %	3	Good
			From 0,15 % to 0,06 %	2	Medium
			Until 0,05 %	1	Low
	INDICATOR	SOCIAL INDICATOR OF THE AGRICULTURAL SECTOR VARIABLE	COMPOSITION	RANGE	LEVEL
	Social (S) Indicator = 1+2 / 2	Balance of ormal jobs/amount invested in electricity	In additionto20	4	High
			From 20 to 16	3	Good
			From15 to 6	2	Medium
			Until 5	1	Low
		Average income/Quantity of GW consumed	In addition to R$ 7,50	4	High
			From R$ 7,50 to R$ 6,01	3	Good
			From R$ 6,00 to R$ 4,01	2	Medium
			Until R$ 4,00	1	Low
	INDICATOR	AGRICULTURAL SECTOR ENVIRONMENTAL INDICATOR VARIABLE	COMPOSITION	RANGE	LEVEL
	Environmental(A) Indicator = 1+2 / 2	Variation in energy efficiency in the sector/ Amount of GW consumed	In addition to 0.25%	4	High
			From0,25% to 0,19%	3	Good
			From0,18% to 0,11%	2	Medium
			Untul 0,10%	1	Low
		Variation in the emission of polluting gases derived from electricity generation	In addition to 30%	4	High
			From 30% to 21%	3	Good

		/ Quant. of GW consumed	From 20% to 16%	2	Medium
					Low
			Until 15%	1	
	INDICATOR	AGRICULTURAL SECTOR POLICY INDICATOR VARIABLE	COMPOSITION	RANGE	LEVEL
	Political (P) Indicator= $\frac{1+2}{2}$	Variation of the equivalent frequency of interruption per consumer unit/ rate variation charged for electricity	In addition to 0,75%	4	High
			From 0,75% to 0,51%	3	Good
			From 0,50% to 0,2%	2	Medium
			Until 0,1%	1	Low
		Variation in duration of interruptions per unit. consumer / variation of the tariff charged for electricity	In addition to 0,6%	4	High
			From 0,50% to 0,5%	3	Good
			From 0,4% to 0,2%	2	Medium
			Until 0,1%	1	Low

Source: Prepared by the authors (2021).

Table 2 shows the construction structure of the electricity sustainability index and indicators for the industrial sector in Pará.

Table 2: Structure of construction of electricity sustainability indicators in the industrial sector of Pará, Brazil.

		ECONOMIC INDICATOR FOR THE INDUSTRIAL SECTOR			
	INDICATOR	VARIABLE	COMPOSITION	RANGE	LEVEL
Índex = $\frac{E+S+E+P}{4}$	Economic (E) Indicator=$\frac{1+2+3}{3}$	GDP/Quantity of KW consumed	In addition to 0.25%	4	High
			From R$ 1,50 a R$ 1,16	3	Good
			From R$ 1,15 a R$ 0,76	2	Medium
			Until R$ 0,75	1	Low
		Quantity of GW consumed/ amount invested in electricity	In additionto120 GW	4	High
			From 120 to 81 GW	3	Good
			From80 to 31 GW	2	Medium
			Until 30 GW	1	Low
		Variation in electricity tariff/ amount invested in electricity	In addition to 0,35 %	4	High
			From 0,35 % to 0,21 %	3	Good
			From 0,20 % to 0,06 %	2	Medium
			Until 0,05 %	1	Low
		SOCIAL INDICATOR OF THE INDUSTRIAL SECTOR			
	INDICATOR	VARIABLE	COMPOSITION	RANGE	LEVEL
	Social (S) Indicator = $\frac{1+2}{2}$	Balance of formal jobs/amount invested in electricity	In additionto75 empregos/milhão investido	4	High
			From 75 to 46	3	Good
			From 45 to 16	2	Medium
			Until 15	1	Low
		Average income/Quantity of GW	In addition to R$ 0,06	4	High
			From R$ 0,06 to R$ 0,05	3	Good
			From R$ 0,04 to R$ 0,03	2	Medium

	consumed	Until R$ 0,02	1	Low
INDICATOR	ENVIRONMENTAL INDICATOR FOR THE INDUSTRIAL SECTOR VARIABLE	COMPOSITION	RANGE	LEVEL
Environmental(A) Indicator = $\frac{1+2}{2}$	Variation in energy efficiency in the sector/Amount of GW consumed	In addition to 0,60%	4	High
		From 0,60% to 0,31 %	3	Good
		From0,30% to 0,07%	2	Medium
		Until0,06%	1	Low
	Variation in the emission of polluting gases derived from electricity generation/ Quant. of GW consumed	In addition to 0,20%	4	High
		From 0,20% to 0,16%	3	Good
		From 0,15% to 0,11%	2	Medium
		Until 0,10%	1	Low
INDICATOR	POLITICAL INDICATOR OF THE INDUSTRIAL SECTOR VARIABLE	COMPOSITION	RANGE	LEVEL
Political (P) Indicator= $\frac{1+2}{2}$	Variation of the equivalent frequency of interruption per consumer unit/ rate variation charged for electricity	In addition to 0,60%	4	High
		From 0,60% to 0,4%	3	Good
		From 0,3% to 0,2%	2	Medium
		Until 0,1%	1	Low
	Variation in duration of interruptions per unit. consumer/ variation of the tariff charged for electricity	In addition to 0,40%	4	High
		From 0,40% to 0,21%	3	Good
		From 0,20% to 0,2%	2	Medium
		Until 0,1%	1	Low

Source: Prepared by the authors (2021).

Table 3 shows the construction structure of the electricity sustainability index and indicators for the industrial sector in Pará.

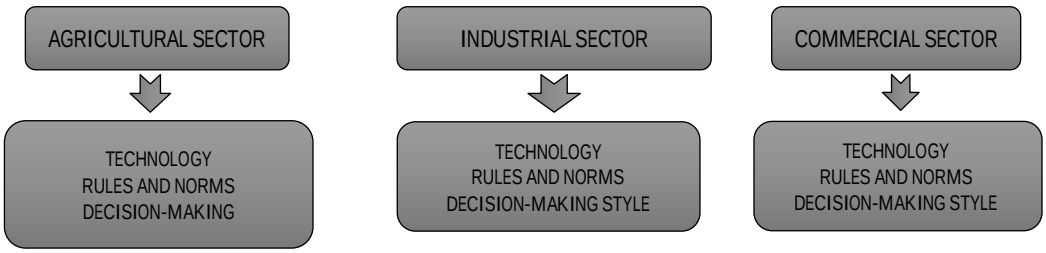
Table 3: Structure of construction of electricity sustainability indicators in the commercial sector of Pará.

	INDICATOR	COMMERCIAL SECTOR ECONOMIC INDICATOR VARIABLE	COMPOSITION	RANGE	LEVEL
Índex = $\frac{E+S+E+P}{4}$	Economic (E) Indicator=$\frac{1+2+3}{3}$	GDP/Quantity of KW consumed	In addition to R$ 1,50	4	High
			From R$ 1,50 to R$ 1,16	3	Good
			From R$ 1,15 to R$ 0,76	2	Medium
			Until R$ 0,75	1	Low
		Quantity of GW consumed/amount invested in electricity	In addition to20 GW	4	High
			From 120 to 81 GW	3	Good
			From 80 to 31 GW	2	Medium
			Until 30 GW	1	Low
		Variation in electricity tariff/amount invested in electricity	In addition to 0,35 %	4	High
			From 0,35 % to 0,21 %	3	Good
			From 0,20 % to 0,06 %	2	Medium
			Until 0,05 %	1	Low

INDICATOR	COMMERCIAL SECTOR SOCIAL INDICATOR VARIABLE	COMPOSITION	RANGE	LEVEL
Social (S) Indicator = $\frac{1+2}{2}$	Balance of formal jobs/amount invested in electricity	In addition to 75	4	High
		From 75 to 46	3	Good
		From 45 to 16	2	Medium
		Until15	1	Low
	Average income/Quantity of GW consumed	In addition to R$ 0,06	4	High
		From R$ 0,06 to R$ 0,05	3	Good
		From R$ 0,04 to R$ 0,03	2	Medium
		Until R$ 0,02	1	Low
INDICATOR	**COMMERCIAL SECTOR ENVIRONMENTAL INDICATOR VARIABLEL**	**COMPOSITION**	**RANGE**	**LEVEL**
Environmental(A) Indicator = $\frac{1+2}{2}$	Variation in energy efficiency in the sector / Amount of GW consumed	In addition to 0,60%	4	High
		From 0,60% to 0,31 %	3	Good
		From 0,30% to 0,07%	2	Medium
		Até 0,06%	1	Low
	Variation in the emission of polluting gases derived from electricity generation / Quant. of GW consumed	In addition to 0,20%	4	High
		From 0,20%to 0,16%	3	Good
		From 0,15% to 0,11%	2	Medium
		Untul 0,10%	1	Low
INDICATOR	**COMMERCIAL SECTOR POLICY INDICATOR VARIABLE**	**COMPOSITION**	**RANGE**	**LEVEL**
Political(P) Indicator= $\frac{1+2}{2}$	Variation of the equivalent frequency of interruption per consumer unit/ rate variation charged for electricity	In addition to 0,60%	4	High
		From 0,60% a 0,4% 3	3	Good
		From 0,3% to 0,2%	2	Medium
		Untiul0,1%	1	Low
	Variation in duration of interruptions per unit. consumer/variation of the tariff charged for electricity	In addition to 0,40%	4	High
		From 0,40% to 0,21%	3	Good
		From 0,20% to 0,2%	2	Medium
		Until0,1%	1	Low

Source: Prepared by the authors (2021).

In the methodological strategy of this study, each sector of economic activity was assessed based on the components of the decision structure proposed by Silva (2013), in order to favor a decision model based on the results of the indicators (Figure 1).



Source: Prepared by the authors (2021).

Figure 1: Structure of the decision-making process in public management.

Next, the results and discussions relevant to the calculation of energy sustainability indicators and the provision of subsidies to the decision-making process in the electricity sector will be presented, Which considers the intricacies of technology, rules and

IV. Results and Discussions

This section will be composed, firstly, by the presentation of the results of the sectorial indicators of electric energy sustainability and their analysis, in the scope of each economic activity sector. Then, a decision-orientation model will be presented, which considers the intricacies of technology, rules and standards, and decision-making style, fed by the results of the sector sustainability indicators measured for the State of Pará, between 2010 and 2019.

Below, in Tables 4 and 5, the results of the investigation on energy sustainability indicators in the agricultural sector of the State of Pará are presented.

Table 4: Score of ranges for calculating energy sustainability indicators in the agricultural sector in Pará (2010-2019).

INDICATOR	VARIABLE	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
ECONOMIC	GDP/Quantity of KW consumed	2	2	3	4	4	3	3	2	1	1
	Quantity of GW consumed/amount invested in electricity	4	4	3	3	4	4	4	2	2	2
	Variation in electricity tariff/amount invested in electricity	3	3	2	3	4	2	2	1	1	1
	Balance of formal jobs/amount invested in electricity	1	2	2	3	4	4	4	2	1	1
	Average income/Quantity of GW consumed	2	3	3	4	2	2	2	4	4	4
	Variation in energy efficiency in the sector / Amount of GW consumed	2	2	4	2	2	3	3	3	2	1
ENVIRONMENTAL	Variation in the emission of polluting gases derived from electricity generation / Amount of GW consumed	4	4	4	4	3	2	2	1	1	1
POLITICAL	Variation in FEC per consumer unit / variation in the tariff charged for energy	1	1	2	3	4	2	2	2	1	2
	Variation of DEC per consumer unit / variation of the tariff charged for energy	1	2	3	4	4	4	3	3	1	1

Source: Prepared by the authors (2021). Legend: 4= High Level; 3= Good Level; 2= Medium Level; 1= Low Level.

In the agricultural sector, the highlight was the social and environmental dimensions, with positive results, predominantly registering indicators with levels between Good and Medium.

Table 5: Energy sustainability indicators in the agricultural sector (2010-2019).

INDICADOR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Economic	Good	Good	Good	Good	High	Good	Good	Medium	Low	Low
Social	Medium	Medium	Medium	Good	Good	Good	Good	Medium	Medium	Medium
Environmental	Good	Good	High	Good	Medium	Medium	Medium	Medium	Medium	Low
Political	Low	Low	Medium	Good	High	Good	Medium	Medium	Low	Low

Source: Prepared by the authors (2021).

In the agricultural sector, the highlight was the social and environmental dimensions, with positive results, predominantly registering indicators with levels between Good and Medium. In the years 2018 and 2019, the panorama changed as there were records of Low level indicators in the economic, environmental and political dimensions in the sector. The environmental dimension is a concern regarding sustainability and the possibility of measurement in this study is in line with the reality portrayed that ways to measure sustainable development are being structured and tested in various parts of the world (Lira, 2008). The political dimension was the one with the most weaknesses in the period studied. These weaknesses reveal the inadequate energy supply of a large portion of Pará society, which influences public management with lesser decision-making power. Thus, part of society ends up benefiting at the expense of others, demonstrating the influence of different ideologies of groups that interfere with more decision-making power in public management (Schultz, 2016).

Below, in Tables 6 and 7, the results of the investigation on energy sustainability indicators in the industrial sector of the State of Pará are presented.

Table 6: Score of ranges for calculating energy sustainability indicators of the industrial sector in Pará, Brazil (2010-2019).

	VARIABLE	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Economic	GDP/Quantity of KW consumed	2	2	2	3	3	2	2	4	3	3
	Quantity of GW consumed/ amount invested in electricity	4	4	3	3	3	2	2	1	1	1
	Variation in electricity tariff/amount invested in electricity from	3	3	2	3	3	4	3	1	1	1
Social	Balance of formal jobs/amount invested in electricity	4	4	2	2	1	4	2	2	2	1
	Average income/Quantity of GW consumed	1	2	2	2	1	1	3	3	4	2
Environmental	Variation in energy efficiency in the sector/Quantity of GW consumed	2	3	1	1	4	1	3	1	4	2
	Variation in the emission of polluting gases derived from electricity generation /	2	3	4	2	1	1	2	2	2	2

Political	Amount of GW consumed										
	Variation in the equivalent frequency of interruption per consumer unit/variation in the tariff charged for electricity	1	1	4	4	2	1	2	4	4	3
	Variation in duration of interruptions per consumer unit/variation in tariff charged for electricity	1	2	4	4	1	2	3	3	4	4

Source: Prepared by the authors (2021). Legend: 4= High Level; 3= Good Level; 2= Medium Level; 1= Low Level.

In the industrial sector, the positive highlight was the economic dimension, also with a predominance of Medium and Good levels. The political dimension was the one with the most weaknesses in the sector during the period analyzed.

Table 7: Energy sustainability indicators in the industrial sector (2010-2019).

INDICATOR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Economic	Good	Good	Good	Good	Good	Good	Good	Medium	Medium	Medium
Social	Medium	Good	Medium	Medium	Low	Medium	Medium	Medium	Good	Low
Environmental	Medium	Good	Medium	Low	Medium	Low	Medium	Low	Good	Medium
Polítical	Low	Low	High	High	Low	Low	Medium	Good	High	Good

Source: Prepared by the authors (2021).

The indicators measured reveal an important responsibility to the framework of environmental unsustainability insofar as they point to a profile endowed with large proportions of consumption, added to the relatively low energy yields verified in the analyzed period. The encouragement of mechanisms that strategically redirect the industrial profile of Pará to the condition of contributing to income deconcentration could be operated by increasing the state tax burden for exports of heavy industry products from Pará. The change in the industrial profile would occur through the absence of tax incentives for the segments identified by the study: ferroalloy, aluminum, steel, pulp and paper and chemical products, and the provision of these incentives to the food and beverage, textile and cement industries. The industrial profile of Pará signals the absence of priority aspects to the development process, particularly in relation to the variables that affect the sustainability of the sector, which is in line with the considerations of several authors on the association between energy use and development (Camargo, Ugaya, Agudelo, 2004; Moldan, Janousková, Hák, 2012; Cornescu, Adam, 2014; Silva et al., 2018).

Below, in Tables 8 and 9, the results of the investigation on energy sustainability indicators in the commercial sector of the State of Pará are presented.

Table 8: Score of ranges for calculating energy sustainability indicators of the commercial sector in Pará, Brazil (2010-2019).

	VARIABLE	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Economic	GDP/Quantity of KW consumed	1	1	2	2	2	3	3	3	4	3
	Quantity of GW consumed/ amount invested in electricity	3	4	3	3	3	2	2	1	1	2
	Variation in electricity tariff/	3	3	1	4	4	3	2	2	1	2

	amount invested in electricity										
Social	Balance of formal jobs/ amount invested in electricity	4	4	3	3	3	3	2	1	2	2
	Average income/ Quantity of GW consumed	1	1	2	2	2	3	3	4	4	4
Environmental	Variation in energy efficiency in the sector/ Quantity of GW consumed	2	3	1	4	2	2	2	3	2	2
	Variation in the emission of polluting gases derived rom electricity generation/ Amount of GW consumed	3	3	4	4	3	2	3	2	2	1
	Resultados de tradução	1	1	2	4	1	1	2	3	2	2
Political	Variation in the equivalent frequency of interruption per consumer unit/variation in the tariff charged for electricity										
	Variation in duration of interruptions per consumer unit/ variation in tariff charged for electricity	1	2	3	4	1	4	3	2	1	1

Source: Prepared by the authors (2021). Legend: 4= High Level; 3= Good Level; 2= Medium Level; 1= Low Level.

In the commercial sector, positive attention was given to the economic and social dimensions, registering indicators of Medium and Good levels. The political dimension, like other sectors, was the one that presented the most difficulties.

Table 9: Energy sustainability indicators in the commercial sector (2010-2019).

INDICADOR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Economic	Good	Medium	Medium	Good	Good	Good	Medium	Medium	Medium	Medium
Social	Medium	Medium	Medium	Medium	Medium	Good	Medium	Medium	Good	Good
Environmental	Medium	Good	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
Político	Low	Low	Medium	High	Low	Medium	Medium	Medium	Low	Low

Source: Prepared by the authors (2021).

The decentralization of energy planning, through the creation of the State Energy Policy Council (CEPE), would ensure that the guidelines and strategies designed for the electricity sector in Pará were conducted not only in accordance with the federal government's global interests, but also in a manner to ensure compliance with the demands of society in the state supplying this electricity. What meets the concerns of managers to achieve qualitative results in public management with regard to financial resources applied in the territory (Mafra; Silva, 2004).

In Table 10, below, a structure for decision-making guidance based on the results of the sectorial indicators of sustainability of electricity in Pará, measured in the period from 2010 to 2019, is presented. Suggestions for alternative actions within each of the sectors of economic activity and that considers the economic, social, environmental and political

dimensions, have the purpose of making corrections in the efficiency of the relations between electricity and development, in order to contribute to the increase in the level of these indicators.

Table 10: Framework for decision-making guidance based on the results of the sectorial indicators of sustainability of electricity in Pará.

SETOR	DIMENSION	TECHNOLOGY (Result of indicators)	COMPONENTS DECISION PROCESS RULES AND RULES (Legal Limits)	DECISION-MAKING STYLE (Concentration of power)	SUGGESTION OF ALTERNATIVES
AGRICULTURAL	ECONOMIC	Predominace in GOOD and LOW levels in the period analyzed.	1. Law no. 10,438, of 2002, provides a resource fund for energy development controlled by Eletrobras. 2. Lack of integration between energy policy and public development policies 3. Law no. 9,991, of 2000, assigned the electric energy distributor the obligation to collect resources from consumers and invest 0.5% of its revenue in energy efficiency projects (Aneel, 2018).	1. Absence of a council at the state level to establish local guidelines for energy policy. 2. The nature of the federal government's investments in electricity does notconsider the local agricultural profile.	1. Increased investments in electricity associated with GDP expansion in the sector, through incentives to new agricultural enterprises. 2. Installation of electricity consuming units in rural settlements integrated to the production segment of the main local production chains. 3. Promotion of energy efficiency incentives seeking to reduce dependence on energy imports 4. Subsidies of 10 million reais for the start of operations to generate alternative energy sources in the sector, notably solar and biomass, with the intention of reducing electricity costs in the long term.
	SOCIAL	Predominance in GOOD and MEDIUM levels in the periodanalyzed .	1. Lack of autonomy in energy policy associated with development. 2. Lack of integration between energy policy and public development policies.	1. The autocratic profile of federal government investments does not consider the generation of jobs through energy production chains.	1. Expansion of the use of alternative generation sources to water sources as catalysts for direct and indirect jobs. 2. Favoring incentives for energy efficiency in order to create jobs in the sector.
	ENVIRONMENTAL	Predominance in GOOD and MEDIUM levels in the period analyzed.	1. Lack of autonomy in energy and environment policy. 2. Lack of integration between energy policy and public development policies	1. Absence of a council at the state level to create local guidelines thatre concile energy policy and the agricultural sector.	1. Implement investments in energy efficiency with the purpose of reducing pollution levels. 2. Subsidies of 10 million reais for the start of operations to generate alternative energy sources in the sector, notably solar and biomass.

INDUSTRIAL	POLÍTICA	Predominance in MEDIUM and LOW levels in the period analyzed.	1. Absence of state autonomy in energy policy. 2. Lack of integration between energy policy and effective citizen participation.	1. Lack of a state council to create mechanisms for associating the quality of electricity services and the tariff charged.	1. Creation of the State Energy Policy Council (CEPE). 2. Regulation, by Aneel, of tariffs based on the quality of supply. 3. Quality could be verified by the number of interruptions in the supply of electricity and the duration of these interruptions.
	ECONÔMICA	Predominance at GOOD level. MEDIUM level in recent years of the period analyzed.	1. Law no. 10,438, of 2002, provides a resource fund for energy development controlled by Eletrobras. 2. Lack of integration between energy policy and public development policies 3. Law No. 9,991, of 2000, assigned the energy distributor the obligation to collect resources from users and invest 0.5% of its revenue in efficiency projects (Aneel, 2018).	1. Absence of a council at the state level to establishan association between energy policy and the local industrial profile.	1. I encourage mechanisms that direct the industrial profile of Pará to the condition of contributing to the deconcentration of income, that is, promoting changes in the composition of exports in the heavy industry. 2. Promotion of energy efficiency incentives seeking to reduce dependence on energy imports
	SOCIAL	Predominance at MEDIUM level in the period analyzed.	1. Lack of autonomy in energy policy associated with development. 2. Lack of integration between energy policy and public development policies	1. The autocratic profile of federal government investments does not consider the generation of jobs through energy production chains. 2. Absence of a state council to establish local guidelines thatre concile energy policy and the sector.	1. Expansion of the use of alternative generation sources to water sources as catalysts for direct and indirect jobs. 2. Reduced working hours in energy-intensive industries to generate new jobs. 3. Favoring incentives for energy efficiency in order to create jobs in the sector.
	ENVIRONMENTAL	Predominance in MEDIUM and LOW levels in the period analyzed.	1. Lack of autonomy in energy and environment policy. 2. Lack of integration between energy policy and public development policies	1. Absence of a council at the state level to establish local guidelines for the containment of environmental impacts caused by the energy input.	1. Incorporation of compensatory devices for environmental costs in the sector based on accounting mechanisms for price formation. 2. Implement investments in energy efficiency with the purpose of reducing pollution levels. 3. Subsidies of 10 million reais for the start of operations to generate alternative energy sources in the sector, notably solar and biomass.

COMMERCIAL	POLÍTICA	Predominance in levels ranging from HIGH to LOW in the period analyzed.	1. Lack of integration between energy policy and effective citizen participation. 2. Absence of state autonomy in energy policy.	1. Lack of a state council to establish mechanisms for associating the quality of electricity services and the tariff charged in the sector.	1. Creation of the State Energy Policy Council (CEPE). 2. Regulation, by Aneel, of tariffs based on the quality of supply, where the referred quality can be verified through the number of interruptions in the supply of electricity and the duration of these interruptions.
	ECONÔMICA	Predominance in GOOD and MEDIUM levels in the period analyzed.	1. Law no. 10,438, of 2002, provides a resource fund for energy development controlled by Eletrobras. 2. Lack of integration between energy policy and public development policies 3. Law No. 9,991, of 2000, assigned the electricity distributor the obligation to collect funds from consumers and invest 0.5% of its revenue in energy efficiency projects (Aneel, 2018)	1. Absence of a council at the state level to establish an association between energy policy and the profile of local commerce.	1. Increased investments in electricity associated with GDP expansion in the sector, in order to promote programs for the use of alternative energy to offset existing electricity bills. 2. Promotion of energy efficiency incentives seeking to reduce dependence on energy imports
	SOCIAL	Predominance in GOOD and MEDIUM levels in the period analyzed.	1. Lack of autonomy in energy policy associated with development. 2. Lack of integration between energy policy and public development policies	1. Absence of a council at the state level to establish local guidelines thatre concile energy policy and the sector.	1. Linking of special reduced tariff bands for companies in the sector with a large number of jobs. 2. Favoring incentives for energy efficiency in order to create jobs in the sector.
	ENVIRONMENTAL	Predominance at MEDIUM level in the period analyzed.	1. Lack of autonomy in energy and environment policy. 2. Lack of integration between energy policy and public development policies	1. Absence of a state council to establish local guidelines for the containment of environmental impacts caused by the energy input.	1. Subsidies of 10 million reais for the start of operations to generate alternative energy sources in the sector, notably solar and biomass. 2. Implement investments in energy efficiency with the purpose of reducing pollution levels.

POLÍTICA	Predominance in LOW and MEDIUM levels in the period analyzed.	1. Absence of state autonomy in energy policy. 2. Lack of integration between energy policy and effective citizen participation.	1. Lack of a state council to establish mechanisms for associating the quality of electricity services and the tariff charged in the sector.	1. Creation of the State Energy Policy Council (CEPE). 2. Regulation by Aneel of tariffs based on the quality of supply. 3. The quality could beverified through the number of interruptions in the supply of electricity and the duration of these interruptions.

Source: Prepared by the authors (2021).

The actions based on the results of the sectorial indicators of electricity sustainability for the State of Pará were divided into three stages: short, medium and long term. In the short term, the study recommends: a) decentralization of energy planning through the creation of the State Energy Policy Council (CEPE); b) establishment of a local integrated strategic planning model that uses as an instrument the methodological framework for the construction of energy sustainability indicators and indices, proposed in this article; c) maintain the flow of investments in electricity to maintain Gross Domestic Product - GDP expansion in all sectors; and d) regulation of tariffs based on the quality of supply.

In the medium term, the following are indicated: a) the implementation of social sustainability programs with the energy environment of the agricultural sector, including production chains, and of the industrial sector, reducing the workload in energy-intensive industries; b) incorporation of compensatory devices for environmental costs in the industrial sectors.

In the long term, it is recommended: a) the encouragement of mechanisms that strategically direct the industrial profile of Pará, promoting changes in the composition of heavy industry exports (from the increase in the state tax burden for exports of heavy industry products from Pará) and changing the industrial profile, in order to withdraw tax incentives to the segments identified by the study: ferroalloy, aluminum, steel, pulp and paper and chemical products, and the provision of these incentives to the food and beverage, textile and cement industries, sectors these indicated by the results of the analyzes carried out); and b) increase in the energy efficiency of electricity through credit lines to agricultural enterprises that intend to exchange equipment with high electricity consumption.

V. Final Considerations

The study elaborated an original decision planning model based on sectorial indicators of electricity sustainability in the state of Pará, capable of contributing to the planning of public actions for sustainable development in Pará, according to the results of these indicators measured by sector of economic activity.

The indicators calculated in this investigation revealed a particular reality in each sector of economic activity in the State of Pará. In the agricultural sector, the highlight was the social and environmental dimensions, with positive results, registering levels between Good and Medium. In the industrial sector, the positive highlight was the economic dimension, also with a predominance of Medium and Good levels. In the commercial sector, the positive highlight was the economic and social dimensions, recording, in the same way, Medium and Good levels. The political dimension was the one that showed the most weaknesses in the period surveyed, in all sectors of economic activity in Pará.

The study also presented a decision-making model that suggested actions linked to increasing energy autonomy in Pará, redirecting the industrial profile, including compensatory devices for environmental costs, directing investments to increase GDP in the reality of each sector of economic activity, among other recommendations. The article contributed through: an originality of analysis that reveals the strategic usefulness of knowing the energy specificities of each economic sector and how electricity reflects on the productive processes of each sector; a reinterpretation of the Brazilian energy plan from a decision analysis dynamic that considers the regional specificities for the strategic use of the energy input; and the possibility of using a decision-making model in the electricity sector applicable to any state in Brazil.

New investigations can follow the methodological dynamics presented in this study and the residential sector would be the one that would most add to the deepening of the understanding of this theme. The residential sector comprises a relevant environment for examining the reality of meeting basic energy needs, as it identifies the socioeconomic profile of households in a given population and their conditions of access to energy input.

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Urban Densification and Social Sustainability: A Case Study of Dhaka

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Abstract- Dhaka is regarded as a thriving megacity of South Asia. The key challenges that the bustling hub is confronted with are land scarcity and the growing population. With limited land supply, the city is copping to accommodate its ever-growing population through two development strategies, namely densification and vertical expansion. Densification is regarded as an effective tool in guiding the urbanization process, while vertical expansion can be considered as a complementary part of this strategy. When it comes to application in an urban environment as a strategy, the subjective attributes of density need to be taken into consideration along with its objective aspects. As the concept of crowdedness differs generally among people belonging to different cultures, statuses, ethnicity, and geographic location, the livable density standard is also supposed to vary accordingly. The concept of habitable density for any community is profoundly related to the various aspects of social sustainability. Since densification has been taking place in Dhaka without any guidelines, the livability conditions with regards to the social sustainability of the city dwellers are largely compromised. Therefore, there is an urgent need to assess the sustainability of the residential areas of Dhaka, which have been developing as a by-product of the unguided densification process taking place over the recent decades.

Keywords: *densification, social sustainability, megacity, density.*

GJHSS-B Classification: *FOR Code: 040699*

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Strictly as per the compliance and regulations of:

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Keywords: densification, social sustainability, megacity, density.

I. Introduction

Since the inception of Dhaka as a small trade center at the bank of river Buriganga, the city has undergone various stages of expansion under the different ruling regimes over the past 400 years. Reaching its spatial limits on the three sides due to topographical constraints, the city at present is left with the option of expanding northwards only. But the further expansion of the metropolis is not deemed feasible given the required infrastructure cost and loss of valuable agricultural land. Therefore, densification through vertical extension seemed to be a more practical solution to address the problem. Consequently, densification started in the mid-90s and gained momentum over the subsequent decades, eventually turning the residential areas into a jungle of high-rise buildings. Two distinctive land-use patterns govern the urban planning of Dhaka identified through the road network system. The land-use planning of Old Dhaka around the historic core was based on organically developed road network system comprising of an array of narrow lanes. In contrast, a regular grid iron pattern of road layout dominates in the planning of New Dhaka. Densification has not only resulted into a change in the urban fabric of these areas but also has a significant impact on the factors of social sustainability of these residential areas.

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II. Methodology

The paper examines the effects of the ongoing densification process on the social sustainability of the residential areas of Dhaka Megacity. Seven *wards* (municipal administrative units) were selected as study areas based on varied density profile, built form type and settlement age where ward, 77 and 78 (Luxmi Bazaar and Wari) house the oldest residential areas, ward no. 49, 19 and 18 (Dhanmondi, Banani and Gulshan) represents new residential areas and ward no. 1 and 6 (Pallabi, and Uttara) are among the more recently developed residential areas. This study attempts to assess the social sustainability of these residential areas by examining six selected aspects which include community facilities, amount of living space, health problems, community stability, social cohesion, and sense of safety. The analysis is carried out in two phases. The first phase contains the analysis of residents' perceptions about the prevailing density and the selected aspects pertinent to social sustainability through assessing the responses from the questionnaire survey and corroborating them with the informal qualitative interviews of the residents. The second phase examines the correlation between density attributes (physical and perceived) and sustainability aspects based on the residents' satisfaction level of the selected aspects of social sustainability. Depending on the limitation of availability of ready data Gross population density of study wards has been selected for assessing the physical density attributes. Perceived density is assessed from two levels which are perception about neighborhood density and perception about dwelling density. Extensive field survey, qualitive interviews with the residents and questionnaire survey provided the primary data for analysis while secondary data were accumulated from various published literature, government records, and archives. Base maps of the study areas and other spatial data were collected from RAJUK, PWD, Dhaka North and South

City Corporations. Since the research deals with many variables, only the most relevant ones were selected for the correlation analysis. These findings are then interpreted in detail with their theoretical underpinnings to provide an insight into the consequences of the ongoing densification process in the residential areas of Dhaka, that might serve as a guide for formulating contextualized density standards and effective policies of densification in the future.

III. Exploring the Aspects of Social Sustainability

The social sustainability of the study areas is evaluated through six selected aspects of social sustainability (community facilities, amount of living space, health problems, community stability and social cohesion, and sense of safety), and residents' perceptions regarding these issues are explored in the following:

a) *Accessibility to community facilities*

Ensuring access to community facilities is a key factor in the development of socially sustainable communities. Providing these facilities at a local level, in convenient locations, increases their accessibility for users and reduces the need to travel. These facilities further raise the quality of life by creating community cohesion, reducing isolation, reducing fear of crime, and creating opportunities for information sharing and participation in a community activity.

i. *Provision of community facilities*

The existing literature revealed that there has been a shortfall of community facilities in the residential areas from the beginning as the need assessment for social infrastructure was based on the anticipated population growth and did not take into account the flux of immigrating population who came after Independence in 1971. In the absence of proper community facility management and planning instruments, the authority tried to solve the rising crisis by allowing community services to develop with response to demand. Later the plots along both sides of the major thoroughfares were permitted for development as commercial strips. The standards for various community facilities provided in UAP and DAP state only the number and space requirement but do not suggest any guidelines regarding their appropriate locational criteria. Taking advantage of the loopholes in standards and also lax development control measures, the community facilities were not constrained within the commercial strips but started proliferating haphazardly within the residential area itself. This trend of sporadic proliferation of community facilities is taking place regardless of the optimum location, actual demand assessment, and compatibility of the built structure in terms of design and environmental concern. The consequences of such development trend are evident through the over-provision and under-provision of necessary community facilities in the planned and unplanned residential areas of Dhaka.

At present, the spontaneously developed planned residential areas of new Dhaka covers a diverse range of services and activities, including local corner shops, convenience stores, boutique shops, shopping malls, clinics, hospitals, diagnostic centers, GP chambers, schools, colleges, universities, banks, mosques, gymnasiums, community centers, etc. From the survey, it was found that the planned residential areas of new Dhaka (Dhanmondi, Banani, Gulshan, Pallabi, and Uttara) have more than the required number of some selected community facilities such as educational, shopping and healthcare facilities. The number of existing educational and healthcare facilities in the planned residential areas is multiple times greater than the actual requirement in compliance with planning standards. The situation is particularly alarming in the case of Dhanmondi and Banani, where there are 66 schools, 15 colleges, 16 universities, and 53 hospitals in Dhanmondi. At the same time, Banani houses nine universities and numerous primary and secondary schools (Field survey, 2016). Besides this, there are 192 other commercial uses like shopping centers, banks, offices of various organizations in Dhanmondi. DAP prescribes one primary school (1 acre) for a 15000 population and one secondary school (1 acre) for a 23000 population and other facilities on a ward basis requirement.

Except for the few public schools and colleges, most of the existing schools are of private ownership and accommodated in rental multi-storied residential buildings that were neither designed to serve the current purposes nor comply with the required space standards of the facility. Nevertheless, the vast number of educational, healthcare, and other commercial institutions of these residential areas is not only catering to the needs of the neighborhood itself but also the city as a whole (Nancy, 2004). A similar development pattern seems to be occurring in Uttara too. To meet the changing needs initiated by the incoming population, the number of private schools, colleges have increased noticeably within the last seven years in Uttara, that are at present serving mostly the neighborhood needs. Some of these private schools are newly designed buildings that comply with the space standards set for schools. But the universities located here are largely on rental accommodation with no campus and are catering to students from all over the city. The number of private and public schools in Pallabi has not still exceeded the demand of the residential area, but most of them are housed in multi-storied buildings not appropriate to work as educational institutions.

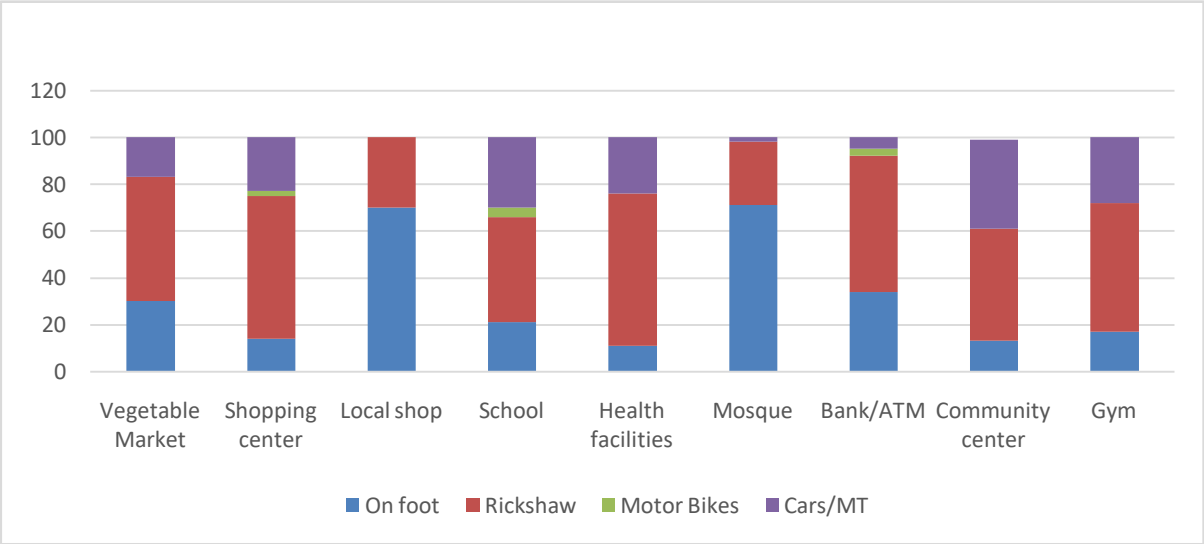
In the case of the old Dhaka, Luxmi Bazaar has more than 11 schools (primary and secondary) of a

reasonably good educational standard within the neighborhood along with colleges and a university located within a 1 km radius of the residential area. Around 70% of the school-going children of this ward travel on foot to reach school, which takes only 5-10 minutes, while the rest uses rickshaw. However, in the planned area of Wari, there is an insufficient provision of primary and secondary schools within the ward itself, and children of the affluent class of this area usually study in the English medium schools beyond their neighborhood precinct, particularly in Motijheel and Dhanmondi, which take about 10- 20 minutes to reach by car. The provision of educational institutions in Old Dhaka meets the standard prescribed in the Dhaka Metropolitan Development Plan (DMDP) in terms of number and space requirement except in Wari. The shopping facilities of the residential areas of Old Dhaka (Wari and Luxmi Bazaar) seems to be adequate in terms of number and scale appropriate to neighborhood requirement. The Luxmi Bazaar, which used to be the Mughal trade center since antiquity continues to function the same. However, the marketplace has evolved and adapted to the needs of the age by accommodating modern chain stores, fast food shops, and small-scale retail markets for clothes and electronic gadgets serving the surrounding middle-class residential areas. A similar transformation has also taken place in Wari, where continuous shopping strips mainly of retail shops, convenience, and chain superstores have formed along the main arterial road (*Rankin street*). In response to the ever-changing consumer trends and demands, the traditional neighborhood grocery and other retail shops of this area have been replaced by the market-driven retail chain stores offering a wide range of goods and services congenial to the modern lifestyle of the residents.

From the survey, it was found that there is a general shortage of authorized municipal *kutcha bazaars* (kitchen market) in both the planned and unplanned residential areas of Dhaka, which led to the set up of unauthorized kutcha bazaars in different locations of the study wards. For instance, due to the absence of authorized *kutcha bazaars* in Dhanmondi, a large portion of the residents has to rely on the roadside unauthorized kitchen markets and push-cart vendors while others travel to the nearby neighborhoods (Jigatola, Rayerbazaar, and Mohammapur) for their daily supply of grocery. The condition of the unauthorized make-shift *kutcha bazaars* is very poor in terms of lack of cleanliness, garbage disposal facilities, drainage provision, toilets, and parking facilities. Furthermore, they cause traffic congestion through illegal encroachment of the road. Currently, the nearest chain superstores have become popular alternative sources for meeting the daily grocery demand. In the case of Wari, there are two big kitchen markets (*Thathari Bazaar* and *Kaptan Bazaar*) within a 5-10 minute distance by rickshaw also with the chain superstores serving the area well. However, the provision of religious structures is adequate where all the study areas have at least one or two mosques within a radius of a quarter to a half-mile from any point within the residential area.

ii. *Accessibility to community facilities in terms of distance*

The intertwined network of roads and *chawks* (nodes) of the traditional neighborhoods attributed to the development of community facilities within the walking radius. According to the response of 52% of the old Dhaka residents, most of the basic facilities can be accessed within less than a 5-minute walk. The nearest available facilities are the local shops located within a walking distance of less than a 5-minutes. In the case of the residential areas of new Dhaka, most of the educational, health, and shopping facilities are located within 5-10 minutes, and facilities like community centers and gymnasiums are located far beyond 10 minutes walking distance, according to 55% of respondents. Similar conditions were observed in Wari with an exception in the provision of an adequate number of schools. Due to this inadequacy, most inhabitants have to send their children to the English Medium Schools of Dhanmondi by car (33%) and rickshaw. On the other hand, in Dhanmondi, Banani, and Gulshan, except for local shops and mosques, other community facilities are located beyond 10 minutes of walking distance. Uttara and Pallabi also have the majority of the community facilities within 11-20 minutes of walking distance. The survey findings indicate that most of the community facilities are located within 5-10 minutes and are availed by both rickshaws and on foot. Facilities like local shops and mosques, which are less than 5 minutes away, are accessed on foot. But schools and health facilities when located within 11-20 minutes distance then around 24-30% residents use cars. The usage of cars are for reaching the school is relatively higher in Dhanmondi, Banani, Gulshan, and Uttara, where most people drop their children at school on their way to work. On the other hand, nearly 40% of the residents of Luxmi Bazaar travel on foot to avail of these facilities while the rest 60% uses rickshaws or motorbikes. The 70% of residents of Wari find a rickshaw to be an easier and quicker mode of travel to reach destinations of 11-20 minutes and above 20 minutes while around 30% rely on their cars.



Source: Field Survey, 2015

Chart 1: Mode of travel used by the respondents to reach the community facilities

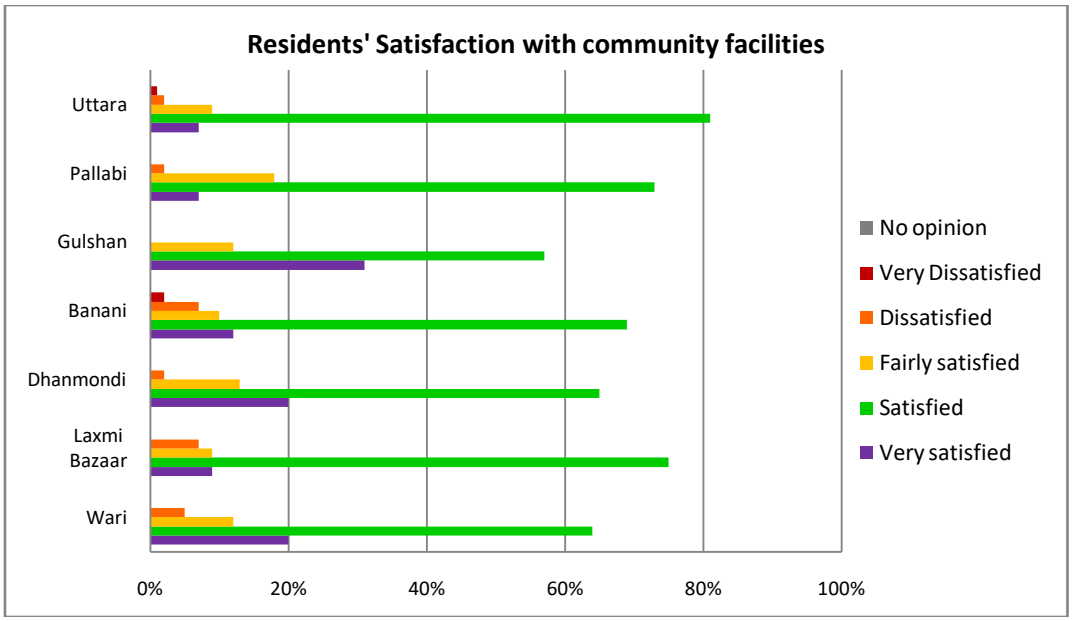
iii. *Residents' Satisfaction with community facilities*

As most of these planned residential areas were initially designed without consideration of proper community facility planning, the later provision of these supporting facilities sprang up from demand and helped to enhance the livability of these neighborhoods. This explains the residents' high satisfaction level regarding community facilities, but at the same time, residents have shown high discontent towards the resultant traffic situation as expressed by the residents -

"I have been living in Dhanmondi since 1981. Earlier, the area was more quiet and serene, but there was a lack of shops except for a handful of local grocery shops on some of the street corners. We used to do most of our shopping from Newmarket. The situation is quite different now where everything from daily food articles to luxurious commodities is available in the area and, is a privilege. But though there is a range of commercial facilities close around due to the traffic jam, which is almost always prevalent in the main roads it takes an unnecessarily long time to reach any of these shopping centers or restaurants even by rickshaw. The situation is even worse if I decide to go by car as the lack of parking is another problem with these shopping centers and restaurants. So even though I wish to go out with my family for recreation in the evening, I don't feel like going when I think of the traffic. This condition is very disgusting and unacceptable." (Interview with a female bank employee, October 2015)

"My house is in Dhanmondi, and I work in both Gulshan and Dhanmondi LabAid hospital in the morning and evening shift, respectively. From my house, any of these two destinations should not take more than 10 to 20 minutes to reach by car. But every day I have to spend at least two hours or sometimes even more in the traffic congestion during the morning and evening peak hours which is simply unacceptable for me. I wonder how people would be traveling in this city after five years from now! "(Interview with a senior doctor, December 2015)

These frequent expressions of discontent from the residents indicate that though the current livability standards of the residential areas have enhanced with the over-provision of community facilities, particularly in the residential areas of New Dhaka.

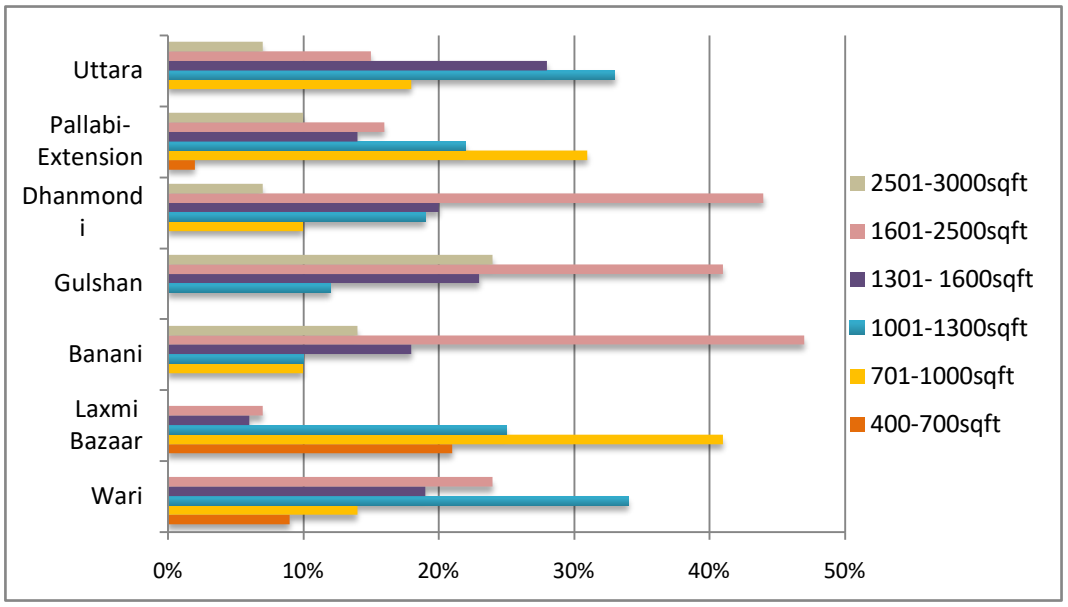


Source: Field Survey, 2015

Chart 2: Respondents' opinion about the satisfaction level of community facilities

b) Amount of living space

The amount of living space is assessed in terms of floor area per person and residents' satisfaction with the size of their dwelling. The former is a measure of the physical density and the latter one represents the residents' perception of density. The perceived density has been measured using three parameters, i.e. perceived neighborhood density, perceived density between building through setback space, and perceived density within the dwelling which provides an insight into the residents' perception of crowding. From the survey, it was found that the dwelling size of the old Dhaka are comparatively smaller than the ones of new Dhaka, where Luxmi Bazaar has the highest percentage (34%) of the lowest size dwellings (400-700 sq.ft.). These turn out to be the half-century-old 2-3 storied red brick buildings where the lower floors are mostly rented to the female college and university students. Maximum dwellings of Wari comprised newly constructed modern midrise (6–8 stories) buildings with apartments ranging between 1000-1600 sq.ft. The majority of the large size apartments (1601-2500 sq.ft. and 2500-3500 sq.ft.) are found in high-class residential areas of Banani (48% and 14%) and Gulshan (41% and 24%), respectively. The proportion of the largest apartments (2500-3500 sq.ft.) is highest in Gulshan. Dhanmondi and Uttara have a relatively high incidence of medium-sized flats (1000 – 1600 sq.ft.) while Pallabi has a moderate proportion of small, medium, and large size apartments with the highest number in the category of 701- 1000 sq.ft. This is because Pallabi is a middle and lower-middle-income residential area where smaller flats are in constant demand for affordable rent structure. Most of the landowners have redeveloped their original two-storied single houses into 6-10 storied houses for financial gain. Maximum plots of Dhanmondi, Uttara, and Pallabi range from 2340-3600 sq.ft. (3.25–5 *kathas*). Usually, the landowners occupy an entire floor for their own residency and subdivide the rest of the floors into economy-size apartments, which explain the existence of various sizes of apartments in these areas. The minimum floor area per person in old Dhaka, usually ranges from 80 sq.ft. to 140 sq.ft. while in new Dhaka the average floor area per person is 200–320 sq.ft.



Source: Field Survey, 2015

Chart 3: Size of flats of the respondents

The household income level also has a significant impact on the household densities as families with low income could only afford smaller dwellings in terms of rental or ownership purposes. A lack of affordability generally affects the amount of living space and results in less floor area per person and household crowding. In the case of Dhaka, less affordable housing and a smaller amount of living space are more an outcome of government policy and the highly active private sector, whose primary goal is to maximize profit rather than creating quality living spaces.

i. *Resident's perception of Density*

Though a large segment of residents of Luxmi Bazaar has the minimum floor space per person, their notion about crowdedness was not as anticipated. Nearly 91% of the inhabitants with an average family size of 1.5 members living in dwellings of 701-1000 sq. ft. find their dwelling size just adequate where only 5% feels it as a little bit crowded. This adaptation to lower floor space per person might be attributed partly to the years of residency of the inhabitants, where around 52% are the 3rd generation of the original inhabitants. The other 38 percentile are mainly the migrants of varied occupational groups (students, service holders) from all over the country who find this size of dwellings quite reasonable with their affordability. This could be a reason for a similar reaction towards dwelling size from this percentile. The average number of apartments in Wari is relatively larger than in Luxmi Bazaar, and around 65% of the inhabitants perceive their flats as fairly spacious. The majority of the residents from mid-density residential areas (Pallabi and Uttara) feel their dwelling size just adequate (49% and 67%) for their family, whereas a higher percentage of the inhabitants of low-density residential areas (Dhanmondi, Banani, and Gulshan) perceive their dwellings as fairly spacious as expected. As shown in the Table 2 there has been about 85% and 90% of the buildings violating the setback rules in Wari and Luxmi Bazaar respectively which contributes to the dense fabric of these residential areas even further. Despite the close juxtaposition of buildings, 46% of the residents of Wari feel that the setback space is okay, while 67% of inhabitants of Luxmi Bazaar have complained about lack of privacy. While there is a significant violation of setback rules in the study areas of New Dhaka too but on average, 52% of inhabitants feel that the setback space is okay.

Table 1: Respondents' perception about their dwelling size

Respondents' opinion about dwelling size				
Location	Fairly spacious	Just adequate	Little bit crowded	Too much crowded
Wari	**65**	31	4	-
Luxmi Bazaar	4	**91**	5	-
Dhanmondi	**56**	39	5	-
Banani	**58**	39	3	-
Gulshan	**77**	23	-	-
Pallabi	32	**51**	17	-
Uttara	31	**67**	2	-

The percentage is based on the number of responses.
Source: Field Survey, 2015

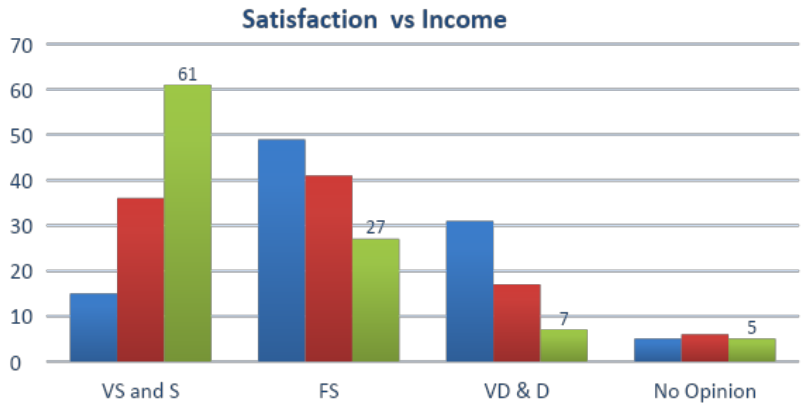


Chart 4: Satisfaction vs Income of the residents

Table 2: Violation of Rules

Sl No.	Thana	Violation of Rules		
		Building Height	Road Encroachment	Setback rules
1.	Luxmi Bazaar	68%	87%	90%
2.	Wari	65%	96%	85%
3.	Dhanmondi	12%	20%	31%
4.	Banani	14%	35%	42%
1.	Gulshan	16%	24%	33%
6.	Uttara	24%	56%	84%
7.	Pallabi	62%	98%	68%

Source: Field Survey 2015

Table 3: Respondents' opinion about setback space

(percentage)

Location	I feel it is okay	I have no problem with it	Hampers privacy	I do not like it at all	No opinion
Wari	46	22	26	4	2
Luxmi Bazaar	9	16	67	8	-
Dhanmondi	58	14	18	9	1
Banani	60	17	12	5	6
Gulshan	61	13	14	2	10
Pallabi	68	11	12	2	7
Uttara	61	18	12	4	5

The percentage is based on the number of responses.
Source: Field Survey, 2015

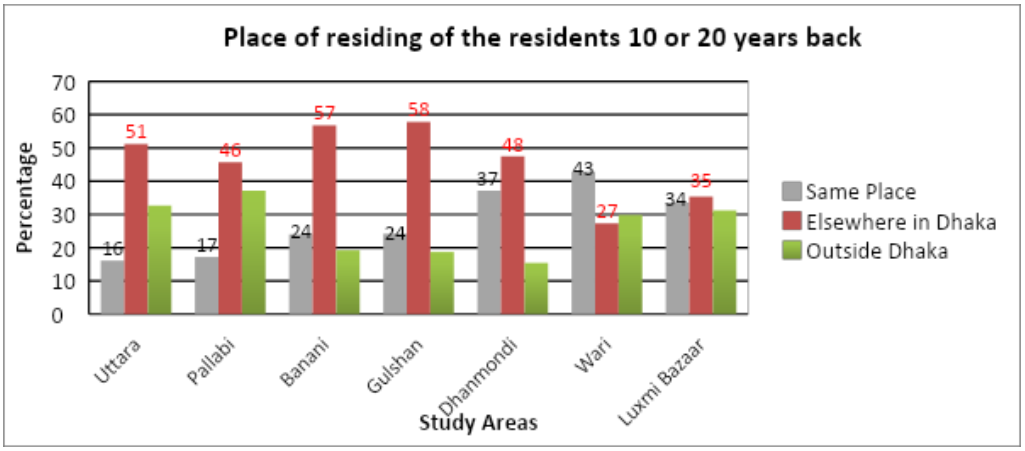
Around 46% of the inhabitants of Luxmi Bazaar do not like the neighborhood density, while 54% of the residents have expressed positive notions about the density. In Dhanmondi, Banani, Gulshan, Pallabi, and Uttara, around 36%, 31%, 44%, 57%, and 56% of inhabitants find the neighborhood density tolerable. Empirical observations found that most of the residents of the new residential areas are living in these areas for less than ten years except Luxmi Bazaar and Wari, where a significantly higher percentage of the residents are original inhabitants of the area (shown in Chart 5). The longer residency period of the inhabitants of old Dhaka could be a reason for higher acceptance of the neighborhood density as satisfactory. On the other hand, most of the newcomers of old Dhaka were found to be belonging to the migrating population from remote district towns and villages who took the transition from rural to urban settings as an up-gradation of lifestyle. This mindset might be partially responsible for the overall higher percentage of satisfaction level of the respondents. The observation also shows around 46–58 percent (Chart 5) of the residents of new residential areas have migrated from elsewhere in Dhaka in pursuit of better living standards, facilities, and social status. Therefore, an enhancement in the type and nature of their new habitat also seems somehow to meet their optimum level of expectation. This progress might be keeping their satisfaction level high despite the various problems associated with the built environment of the new residential areas.

Table 4: Respondents' opinion about the perception of neighborhood density

(percentage)

Location	I am fine with it	It is tolerable	I like it	I have no problem with it	I do not like it	It is intolerable	No opinion
Wari	38	49	-	9	-	-	4
Luxmi Bazaar	-	36	6	12	46	-	-
Dhanmondi	19	36	29	11	3	-	2
Banani	15	31	27	7	20	-	-
Gulshan	18	44	28	8	2	-	-
Pallabi	21	57	10	5	-	-	7
Uttara	27	56	11	6	-	-	-

The percentage is based on the number of responses.
Source: Field Survey, 2015



Source: Field Survey, 2015

Chart 5: Respondents' whereabouts 10 or 20 years back

c) Health of the Residents

According to the self-reported health problems of the survey, a significant number of household inhabitants from all the study areas have complained of at least one family member suffering from stress or pollution-related diseases. In the case of Wari, there is a higher incidence of asthama patients, while in Luxmi Bazaar, people have complained more about stress-related problems, particularly blood pressure. Among the stress-related problems patients, suffering from blood pressure (avg. 50%) and diabetes (avg. 18%) are significantly common in most of the households of the study areas. The majority of the stress-related patients belong to the age group of 20-45, comprising of primarily male and female earning members, housewives, and students. Although most households did not report obesity, the general observation suggested a different picture where a significant percentage of the young generation, especially the children, were found to be obese. The negative response is perhaps due to the unacceptability or reluctance of the parents to perceive their children as obese. Most of the parents of the obese children, when asked, acknowledged their children as healthy. However, obesity is more likely to be associated with the non-physical activities of children. Due to the lack of open space or playgrounds for physical activities, most of the children tend to spend their leisure time playing computer games or watching TV. The indulgence in virtual games rather than physical sports not only affects the physical health but also impedes the mental growth of the children by making them hypersensitive and self-centered. The second highest occurring disease to be reported is asthama, caused by air pollution from the emission of automobiles. Headache is the second most reported pollution-related health disorder among the inhabitants.

The catalyst of blood pressure is stress and anxiety. People of this city, in general, are undergoing an urban lifestyle that is very demanding and competitive, where stress and anxiety disorder has become inevitable. Within this context, if the built environment fails to provide a variety of ample open spaces that work as an antidote to stress, then that community becomes more prone to a stressful psychological state. The lack of sufficient breathing spaces, however, might explain the high incidence of blood pressure in the most unlikely age group (25 – 40 years) of the study areas. The high-

income group is more devoted to sedentary jobs and automobile-dependancy, contributing to more physical idleness, which is reflected by the increased number of heart disease and blood pressure patients in the high-income but low-density residential areas of Gulshan, Banani, and Dhanmondi, respectively. In Wari and Luxmi Bazaar, where inhabitants reported dissatisfaction towards the size of their dwelling, it can be said that perceived density, the crowding within the house seems to have some degree of a positive relationship with the stress-related health problems of the residents.

Table 5: Self-reported health-related problems of the residents

Location	Health-Related Problems						
	Stress-related diseases				Pollution related diseases		
	Heart disease %	Blood pressure %	Diabetes %	Obesity %	Headache %	Asthma %	Nausea %
Wari	5	55	38	2	12	72	16
Luxmi Bazaar	17	52	27	4	37	41	21
Dhanmondi	6	67	23	5	3	69	28
Banani	4	64	30	2	14	73	14
Gulshan	30	48	21	2	53	32	13
Pallabi	5	42	40	13	13	62	25
Uttara	29	36	18	4	63	24	13

The percentage is based on the number of responses.
Source: Field Survey, 2015

d) Community Stability and Social Cohesion

Community spirit and social cohesion is the fundamental building block of social sustainability. Globalization seems to play a defining role in the current lifestyle of the urbanites by making people increasingly technology-dependent and too much absorbed in the virtual world of digital media-based communication. The frequent and casual visits to relatives and neighbors are being replaced by pre-scheduled visits arranged by cell phone or text messaging. Nowadays, people are more eager to make new social contacts and maintain the established ones through social communication platforms like Facebook, Twitter, and Viber rather than relying on unplanned spontaneous informal meetings in public spaces. Their communication pattern has increasingly become more globally oriented rather than locally focused. This diversion of attention from the immediate neighbors and the neighborhood is the main barrier in forming social cohesion among modern urbanites. The virtual mode of contact speeds up communication but it cannot necessarily develop the social ties that used to be strengthened by the traditional form of informal chats frequently taking place in public places. Nevertheless, the design and accessibility to public spaces also play a crucial role in inviting people towards a more rewarding way of socializing and therefore assist in establishing community sustainability. The survey findings provide an insight into the communication pattern and the type of social cohesion existing in the study areas, which is shown in the Table below:

Table 6: Residents' opinion about the number of social contacts

Location	1- 5 neighbours	6 - 10 neighbours	11- 15 neighbours	Above 15 neighbours
Wari	8	44	31	17
Luxmi Bazaar	3	6	49	42
Dhanmondi	30	29	22	19
Banani	56	31	11	2
Gulshan	69	21	7	3
Pallabi	20	54	21	5
Uttara	65	18	10	7

The percentage is based on the number of responses.
Source: Field Survey, 2015

From Tables 5 and 6, it can be seen that residents of Old Dhaka, in general, maintains a high number of social acquaintances with their neighbors. In Luxmi Bazaar, around 80% of the inhabitants, reported the neighborhood to be very friendly, with 42% of the residents knowing more than 15 neighbors. This higher degree of social cohesion of the area still prevailing today may be attributed to the social and spatial configuration of its past legacy. As Luxmi Bazaar does not have any open space. The neighborhood streets, tea stalls, as well as street corners, traditionally served as places of socializing for the male. The traditional low-

height buildings with shop frontage created a continuous band of vibrant commercial activities flanking the narrow roads on both sides. This type of urbanization pattern contributed to forming the street façade and scale attractive for social gatherings. Women used to socialize with their neighbors from rooftops of their houses as the conservative Muslim and Hindu society of those days did not allow females to spend time outdoors. The close spacing of buildings with almost no setback rather aided in the communication of the women folks between households and nurture close ties with neighbors. This scenario is better expressed from the interview of a senior citizen –

"I have been living in Wari for over 48 years. When I was a girl, we used to play in the inner courtyard of our house with our neighbors' children. The houses were usually two-storied then. My mother and grandmother used to spend leisure time in this courtyard during the afternoon. Often the women folks of the adjacent household would go to their rooftop, and my mother used to converse with them from our courtyard. It was a nice friendly environment for the females. So the female folks did not essentially feel the need for any public open space for informal social interaction. But now, as my family has expanded, we have built this 8-storied building tearing down our anchestral home. The high-rise apartments do not offer that type of space or opportunity for social interaction. I feel pity for my grandchildren who cannot find suitable outdoor spaces for playing and, hence, have to spend most of their time in the confinement of home. "(Interview with a senior resident of Wari, November 2015)

It also somehow fostered a sense of security in the neighborhood through natural surveillance from the immediate neighbors of each household. The long-term residency of the inhabitants in Luxmi Baazar also helped in developing and maintaining this social capital. The respondents of Wari reported the neighborhood to be (57%) moderately friendly, with 44% of residents having 6-10 social contacts within the neighborhood. Despite being a locality of old Dhaka, there is a reduction in the number of social contacts in comparison with Luxmi Bazaar and, the neighborhood is also perceived as moderately friendly by the inhabitants. This anomaly could be partly to the fact that most of the lowrise structures of this posh neighborhood of the past are replaced by high-rise buildings attracting a huge inflow of migrants from all walks of life. The self-contained apartment culture is not conducive to fostering social contact between the new migrants and the native dwellers as it was before in the lowrise dwellings with few inhabitants. On the other hand, there is a class distinction and feeling of overcrowding which acts as a barrier in developing social contacts between the migrants and original dwellers, as pointed out by a resident of Wari -

"We have been living in Wari since our childhood. In those days, the area was remarkably clean, and we used to play in the streets and nearby vacant plots with the neighbours' children. Most of the people living here belonged to an elite social class, and there was a healthy relationship between the neighbors. But now most of the elders of those families have passed away, and most of their children have settled abroad or in other parts of the city giving their plots to the developer for constructing high-rise buildings which they have given on rent. As a result, the area is now crammed with too many people from different social backgrounds with whom you cannot easily mix. Moreover, there is no open space left where we can let our children play, which is depriving the new generation of developing the kind of bonding we used to share with our neighborhood children." (Interview with a resident of Wari, November 2015)

Table 7: Residents' responses regarding the frequency of social interaction

Location	Less than 5	5-10 times	10-15 times	15-20 times
Uttara	63	19	12	6
Mirpur	48	37	10	5
Dhanmondi	59	25	13	3
Banani	67	18	11	4
Gulshan	72	17	8	3
Wari	6	48	37	9
Luxmi Bazaar	-	43	41	16

The percentage is based on the number of responses.
Source: Field Survey, 2015

Though high density has a positive association with social interaction but the findings from Wari indicate that if people somehow feel crowded by the concentration, they tend to establish fewer social contacts (Table 6). On the other hand, the residential areas of new Dhaka with lower density show relatively smaller number of social connections. Most of the inhabitants have Dhanmondi, Banani, Gulshan, and Uttara seem to be known to 1-5 neighbors and perceives the neighborhood as moderately friendly. However, the number of social contacts, which is about 6-10 persons in Pallabi, is higher (64%) than the other study sample wards of Dhaka. Pallabi was designed as a middle-class residential area, and the new migrants of this area also predominantly belong to the middle or lower-middle-income class. People from similar income groups usually share the same values and social status and find it easier to interact with each other. The concentration of similar demographic trait is most likely a reason for developing of a comparatively higher

degree of social interaction in Pallabi than in other residential areas of new Dhaka.

Table 8: Perceived friendliness of the residential areas

Friendliness of the neighborhood			
Location	Not Friendly %	Moderately Friendly %	Very Friendly %
Wari	3	57	37
Luxmi Bazaar	3	17	80
Dhanmondi	4	79	17
Banani	12	69	19
Gulshan	11	81	8
Pallabi	5	64	31
Uttara	9	72	19

The percentage is based on the number of responses.
Source: Field Survey, 2015

Overall, the survey reveals that social capital is more prevalent in the high-density residential areas rather than the low-density residential areas of Dhaka. People living in older neighborhoods with higher site coverage (90% - 100%), such as Wari and Luxmi Bazaar, have a higher number of social contacts within the neighborhoods. On the other hand, in new neighborhoods in residential areas like Dhanmondi, Gulshan, Banani, Pallabi, and Uttara, the number of social interactions is comparatively fewer. Although the result from the correlation test between density and social cohesion indicated positive relation, in reality, it would not be appropriate to attribute the development of social capital to density alone. Built form, design, and provision of public spaces have a strong association with this aspect, as it was found that there was less informal chatting with neighbors in high-rise apartments than in lowrise dwellings. Again, it was also found that despite having high density, there is a considerable reduction in the possibility of a desirable amount of social interaction when the neighborhood is perceived as crowded by its inhabitants. The perception of crowding, therefore, leads to reduced community spirit and social cohesion. This scenario was evident in the blocks with a relatively higher number of high-rise buildings (10-14 storied). Moreover, the notion of class distinction and social status has also been found to be a factor impeding the development of social cohesion in the apartment culture.

Socio-demographic variables such as the number of years of residing in the same neighborhood were found to have a strong positive correlation with the number of social contacts and the amount of informal chatting that residents had within the neighborhood, as evident in Luxmi Bazaar. The research had similar findings with the studies of Bonnes et al. (1991), who observed that the length of time residing in a place has a greater effect on the resident's perception of spatial density than physical density. They also found that with the increase in the duration of residence, the inhabitants become more satisfied with the physic-static spatial density aspects of their residential area. This research found similar observations.

It is worthy to note that among the families living in the residential area for more than 20 years, only the senior-most member claimed to have known more than 15 neighbors. The younger members of these families are mostly acquainted with 6-10 neighbors. Due to the frequent arrival and departure of many new migrants, even the families with 20 years of residency is not able to maintain as many contacts as they used to in the past, as expressed by a senior resident of Dhanmondi –

> *"I came to live in Dhanmondi in 1974 after my marriage. Since then, I have been living here with my family. We were familiar to most of the neighbors along our street at that time as there were only a handful of 1-2 storied houses with few families in our street block. Now, most of those old houses are replaced with high-rise buildings with many new families, new faces. Most of our earlier neighbors had either shifted with their adult children to other places or had passed away. So now, after being in this place for around 41 years, I do not know most of our new neighbors". (Interview with a senior resident of Dhanmondi, December 2015)*

It was also found that family income plays a crucial role in social interaction and community cohesion. Households with lower family incomes had fewer social contacts within the neighborhood. In comparison, while families with higher incomes and living in high-rise apartments had less informal chatting and were perceived as less friendly.

Participation in community events

Community events in the study areas mainly included various religious, national, and seasonal festivals like Milad Mehfils, Handicraft fairs, Durga Puja, Pohela Boishak, Pohela Falgun, Choitro Shronkanti, Ekhushey February (Language Martyrs' Day), Bijoy Dibosh (Victory Day), and local fairs of handicrafts, etc. Besides this, sports tournaments are organized periodically by the local sports clubs, but access and participation in these events are exclusively limited to the members. According to the self-reported statistics of the respondents' involvement in the community events was

found moderate in the study areas. The key reasons for the less engagement in community events were reported to be lack of time and the improper organization of these events. The lack of suitable open and community spaces was also another vital reason. For instance, in Dhanmondi, other than the Rabindra Shorobor and lakeside park, there is no designed open space for community activities in the locality. Most of the existing playfields are illegally occupied by influential sports clubs and, therefore, not available for the residents. Apart from the national and religious festivals, there is a lack of social activities focusing on leisure and craft-related activities, which also positively affects the participation of the residents.

e) *Sense of safety*

The findings of this research illustrated that the residential areas with high gross population density had a positive relationship with the sense of safety, which indicating a low incidence of crime. In contrast, perceived densities are found to have significant negative associations with indicators of the sense of safety. The high level of safety was also affirmed by the interview of the residents of the dense settlement of Luxmi Bazaar and Wari –

> *"We do not usually have any incident of mugging or theft because the thief or mugger is certain to get caught while he tries to run away through the alleys of our neighborhood. There is a substantial presence of people in the alleys most of the time, and the local shopkeepers of the neighborhood grocery and corner shops also keep a good eye on the strangers." (interview with a resident senior government official of Luxmi Bazaar, January 2016)*

> *"I cannot recall any incident of mugging or theft in my neighborhood since I am living here. We feel very safe in that regard. Moreover, there is the "Muchi Potti"* (cobblers' lane) *just beside my house where the cobblers' families have been living. Though they have their single-storied houses along the lane, they use the lane for cooking, gossiping, playing, and usually, the male members sleep in the open alley at night. For their constant presence, we feel extra safe both at night and daytime because no thief or mugger can get past them without being caught." (interview with a housewife of Wari, January 2016)*

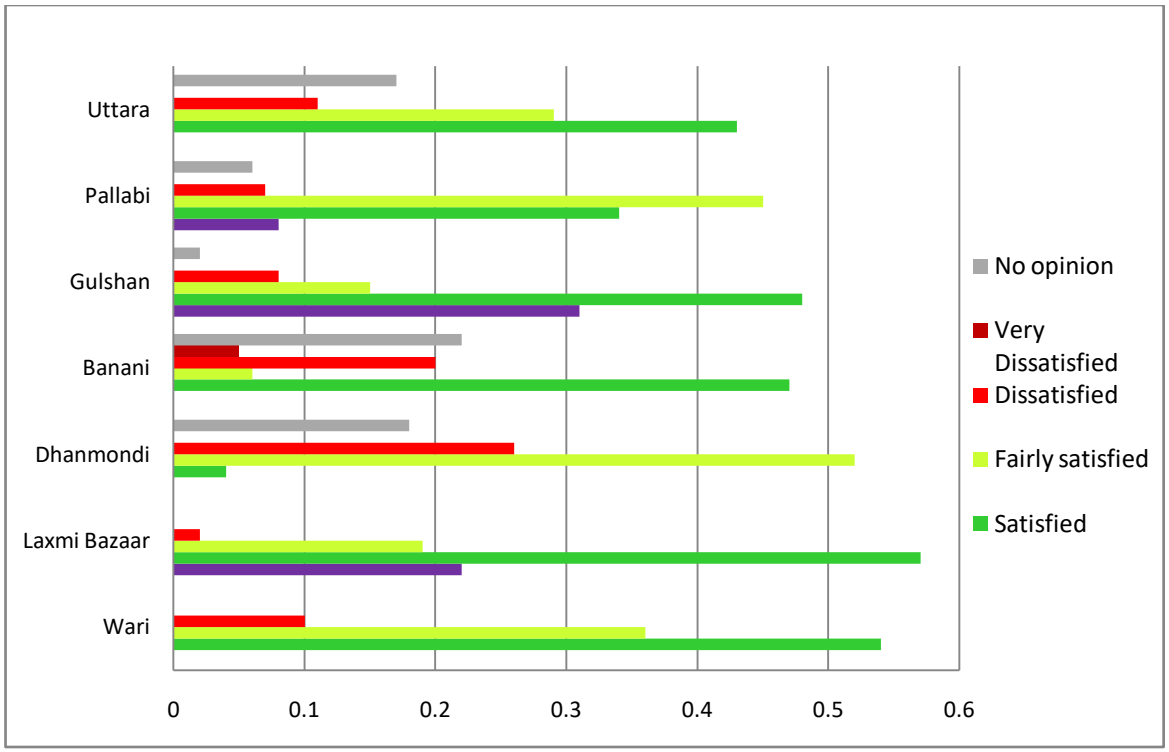
Table 9: Perception of safety by respondents during day and night-time

Time	Uttara	Pallabi	Dhanmondi	Banani	Gulshan	Wari	Luxmi Bazaar
Day time	83	79	87	86	85	91.7	98.1
Night	78	64	72	77	79	92	94.7

The percentage is based on the number of responses.
Source: Field Survey, 2015

The inhabitants of new Dhaka feel relatively less safe both during the day and night-time than the residents of old Dhaka. The existence of gated communities was found more predominant in the study residential areas of new Dhaka (Uttara and Pallabi), where the gates of each neighborhood remain closed during late night. In the residential areas of new Dhaka, the level of street crimes is higher due to the various characteristics of the residential areas. For instance, in Banani and Gulshan, the presence of many banks and posh shopping malls ensures more money transactions which makes these places much targeted for hijacking and mugging. On the other, hand the lack of convenient stores and street activities makes them vulnerable to street crime. Inhabitants refrain from using the parks during the night for the presence of drug abusers. While Uttara and Pallabi both are gated communities, the security of Banani, Gulshan and Dhanmondi largely owes to the presence of security guards in each house and police check posts. However, the crime data indicate a higher incidence of homicides in the new residential areas usually occurring indoors. This intensity of crimes might be attributed to the design of the high-rise apartment buildings generally lacking visual connectivity. The incidence of crime in high-rise buildings often has to do with a lack of connection with the surrounding outdoor spaces and with the residents of the building. Some studies show that the higher the building, the less likely for the residents to reconnect with the surrounding public spaces, and therefore, feel a lack of safety due to this disconnect (Gifford, 2007). The findings of Newman (1982) also asserted that high-rise buildings offer fewer settings where the residents can be relatively free to respond to cues to increase social interaction and therefore reduces the opportunity for natural surveillance. The positive association of duration of tenure in the residential area with the sense of safety has also been asserted by the residents of other study areas as expressed by a resident of Pallabi -

> *"I have been living in this area since my birth. Though the area does not feel as peaceful as before because of all the new people coming here to live but, I stilll feel no lack of safety because we have been familiar to most of the people of the neighborhood from our childhood." (Interview with a resident teacher of Pallabi, December 2015)*



Source: Field Survey, 2015

Chart 6: Residents' satisfaction with neighbhourhood safety and security

On the other hand, in Wari, 18% of the inhabitants have shown dissatisfaction regarding safety while the rest have no complaints. The perceived crowding of the neighborhood could be the cause for the negative responses as expressed by one of the residents –

"There are too many high-rise apartments along our street with too many new unknown faces around. The place is not as it used to be before when there were a handful of families, all familiar to each other in some way. In our childhood, we used to play in these neighborhood streets and our parents did not worry about us because they knew that the children are always under the watchful eyes of neighbors. But now, as I am not able to keep an eye on my children from my flat, and not also familiar with most of the new inhabitants of my neighborhood, I do not feel that safe to let them play alone outside in the street." (Interview with a resident of Wari, November 2015)

Table 10: Regularity of children going out to play in the study areas

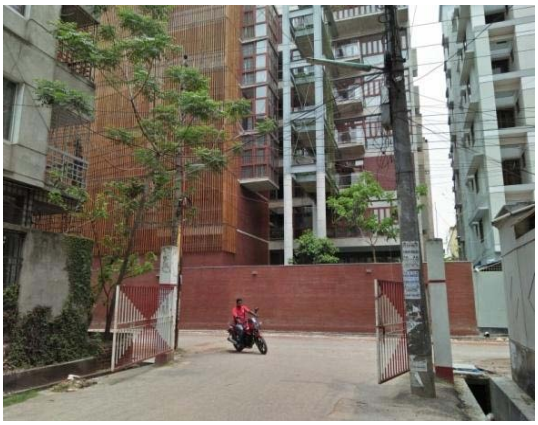
(Percentage)

Location	Every day	2 – 3 days/wk	Rarely	Never
Wari	-	8	11	81
Luxmi Bazaar	3	15	13	67
Dhanmondi	5	10	9	76
Banani	-	7	15	78
Gulshan	-	6	21	73
Pallabi	5	12	15	68
Uttara	2	10	17	71

Source: Field Survey, 2015

This sense of insecurity implies that neighborhoods perceived as crowded have more negative associations with perceived safety during daytime within the locality. High-rise buildings with multi-dwelling units contribute to a higher perception of density. Existing literature reports that the frequency of crime accelerated in the less visible streets from neighboring houses (G. Brown et al., 2004; Perkins et al., 1993), indicating the importance of a surveillance system provided by the residents. Windows facing the road, balconies, or front porches where people can sit and provide eyes on the street does not only give residents opportunities to have informal contacts with neighbors and helps in building local ties but also in the formation of natural surveillance (B. Brown et al., 1998; MacDonald & Gifford, 1989; Perkins et al., 1992, 1993).

Generally, all the apartments of high-rise buildings cannot have street-facing windows and balconies, and thereby the dwellers of high-rise do not have the opportunity of building natural surveillance as the low-rise dwellers have. This disadvantage contributes to a reduced sense of safety suggestive from the expressions of the inhabitants of the study areas. The research also found that on average only 3.75% of children from the study areas go out to play regularly while 9.7% frequently and 14% rarely play outdoors, and on an average, not more than 7% of the parents can watch their children from their apartment while they are playing in the nearby open space (street, park, playground, inside the building premise).



Apart from the lower social cohesion of these neighborhoods, another probable reason could be the lifestyle of the occupants, where a significant percentile of the high-rise residential buildings of area remains vacant during the daytime because of the higher incidents of working couples residing there. The lower rate of occupancy during the daytime attributes to a reduced sense of safety for the inhabitants. The reported robbery cases mainly took place during the daytime when the occupancy rate of the apartments was lower. As mentioned in the previous section, high-rise apartment culture has a lower degree of social cohesion where residents, in general, are not much concerned or feel any responsibility towards what is happening to the neighbors next door. This xenophobic attitude makes the community more prone to bystander effect or "Genovese syndrome", that works as a catalyst for such vicious crimes.

Furthermore, the residents of high-rise apartment culture tend to form social groups according to their income and status leading to centrifugal fragmentation of the society, which in turn impede the development of social capital within the neighborhood as a whole. This attitude increases the opportunity of crimes and thereby lowers the sense of neighborhood safety and security of New Dhaka, where a lower degree of social cohesion is prevalent. This notion of insecurity is reflected from the survey findings of Dhanmondi, Banani, and Uttara, where residents have shown a relatively lower degree of satisfaction regarding the sense of safety. The perceived crowding of people displayed a negative association with perceived safety after dark within the neighborhood, especially where there is inadequate street lighting. This situation was more common in Pallabi, Dhanmondi, and Banani, where people feel unsafe and vulnerable due to vandalism after dark due to the lack of streetlights. This claim is also reflected through the high dissatisfaction level of the residents of these areas, as shown in Chart 6. Income level also influences the sense of safety and security. Neighborhoods with higher floor area per person and with higher family income reported feeling safer and less vandalized, as evident from the residents' responses in Gulshan. Despite the vandalism record is pretty high, which takes place mainly in the commercial strips along the primary road in Gulshan, the neighborhoods of the area have a higher reputation of being safe. Overall, the survey finding suggests that though density is not the sole predictor of safety but high density if not perceived crowded has a positive influence in developing social capital and therefore helps to safeguard the overall security condition of the neighborhood.

IV. Relationship between Density and Sustainability Aspects

The aim of the analysis carried out in this research was to explore the relationship between density and the selected aspects of social sustainability of the study areas. The analysis process used simple correlations (Pearson's correlation) to examine the basic relations among the two sets of key variables of density and aspects of social sustainability. The correlation between the variables of density (physical and perceived) and the indicators of each selected aspect of social sustainability was examined individually and then the overall impact of density was determined from the average values of the indicators of each aspect. The results of the correlation analysis are presented in Table 11 and followed by the interpretation of the findings.

Table 11: Relationship between density and aspects of social sustainability

	List of indicators	Physical density relationship (ward wise - gross population density	Perceived density relationship		The overall impact of density
			Perceived neighborhood density	Perceived density within the dwelling	
Social sustainability					
Accessibility to community facilities	Average distance to nearest daily use shopping center, vegetable/grocery market, health facilities, primary school, mosque, bank, community center, Gymnasium	positive			positive relationship – higher density residential areas have better accessibility
	An average number of shopping centers, vegetable/grocery markets, health facilities, primary schools, mosques, banks, community centers, Gymnasiums per 1000 people.	positive			
Amount of living space	Floor area per person	negative	negative		Negative relationship- higher density residential areas have less amount of living space
	Perceived level of satisfaction with the size of home	negative	negative		
The health of the inhabitants	Number of family members having a stress-related health problem	positive	no impact	positive	Positive relationship – higher density residential areas have more stress or pollution-related health problem
	Number of family members having a pollution-related health problem	positive			
	Number of family members having no health problem	negative	no impact	no impact	
Community stability and social cohesion	Perceived number of social contacts (knowing people) within the last 12 months within the residential area	positive	negative	negative	positive relationship – higher density residential areas have a higher number of social interaction but when the building or neighborhood was perceived as crowded then the number of social contacts are fewer.
	Perceived friendliness of the neighborhood.	positive	positive	no impact	
	Perceived no. of informal chats with neighbors	positive	positive	no impact	
	Self-reported participation in various community events in the last 12 months	no impact	positive		

Sense of safety	Perceived safety within the residential area during daytime	positive	negative	no impact	Positive relationship-higher density residential areas have a higher degree of safety but when perceived as crowded by people the perceived safety was less during both day and night time, perceived
	Perceived safety within the residential area during the night	positive	negative	no impact	
	Perceived vandalism in the neighborhood	no impact	positive	no impact	

Source: Questionnaire survey 2015

From the analysis of the findings displayed in Table 11, it can be seen that most of the selected aspects of social sustainability are positively correlated with density. The aspects of having positive relationships are accessibility to community facilities, the health of the inhabitants, community stability and social cohesion, and a sense of safety. Accessibility of community facilities is found to be positively related to the physical density of the residential areas, which indicates that higher density areas have better access to community facilities in terms of provision and distance.

The aspect of the health of the inhabitants involves three indicators, namely stress-related health problems, pollution-related health problems, and no health problems. The relation between individuals suffering from health problems and density was positive, that signifies that high-density residential areas have more health problems. However, only stress-related health problems exhibit a significant relationship with the perceived density within the dwelling which indicates that if the house is perceived as crowded it tends to add to the stress of the inhabitants. This view is also supported by the literature. The aspect of community stability and social cohesion, in general, demonstrates a significant positive association with physical density where the inhabitants of higher density residential areas displayed a higher number of social contacts and interactions. But contrarily, when the higher density areas are perceived as crowded by the residents the number of social contacts and interactions was significantly decreased. Although the relationship between the participation of the inhabitants in community activities and the perceived density was positive, it was not statistically significant.

One of the reasons for the lower involvement rate was commonly pointed out by the respondents as lack of time, while others held the mismanagement of these events responsible. The sense of safety is strongly associated with physical density indicating that high-density residential areas have a higher degree of protection both during the day and after dark. But when the neighborhood was perceived as crowded, people seemed not to be feeling safe. The perceived vandalism was also found to be increased with the perceived crowdedness of the neighborhood during peak hours. Among the selected aspects of social sustainability, only the amount of living space displays a negative association with both physical and perceived density of the residential areas, which means, the higher the density, the lesser the amount of living space available for individuals as well as less floor area per person. This observation also supports the literature, which suggested that areas with higher net residential densities or population densities are likely to have a lower amount of living space per person.

The relationship of density was examined against four aspects of environmental sustainability, which are accessibility to open space, access to daylight, sense of privacy, and satisfaction with the living condition of the neighborhoods. The accessibility to open space and satisfaction with the living condition of the neighborhoods was found negatively related with density, while the other aspects had a positive relationship. The negative relationships imply that higher density residential areas have less open space. In addition, the higher density areas show less preferrence in terms of attractiveness, cleanliness, architectural character, and privacy. The positive relationship between access to daylight and density signifies that dense residential areas need more artificial lights to be put on during daytime and are subjected to a higher degree of visual obstruction. The measured intensity of noise is positively associated with physical density, but no significant correlation was found between the perceived level of noise and both physical and perceived density.

Among the aspects of economic sustainability, only satisfaction of public transport exhibits a negative association with physical density, which implies that higher density areas are not well served with public transport. In contrast, no significant association was found between density and infrastructure indicating that the provision of utility services (gas, electricity, and water) in the residential areas has not yet gone beyond the threshold. However, higher density is found to be negatively associated with the services like sewerage and garbage disposal of the residential areas of Dhaka.

V. Summary Findings

While summarizing the findings of this research, it is important to point out that though the statistical method has many advantages, the results cannot always portray the real impact as it cannot visualize people's feelings, experience and perception towards a

situation in the practical context which is more subjective by nature. To investigate the consequences of the densification process, it is, therefore, critical to recognize that the findings from the statistical analysis alone are not enough to produce conclusive results in understanding the impacts of such phenomenon on sustainability as it has been confronted by several contradictions reported by the respondents of the study areas. So to get the real picture of the impacts of densification, statistical results from the correlation analysis (Tabel 11) were compared with the contradictions associated with each selected aspect of sustainability which is presented below:

a) Accessibility to Community Facilities

It was evident from the statistical findings that higher gross residential densities had positive impacts on access to facilities and amenities at the neighborhood level, which supposedly enhances the livability as widely supported by the literature. Various theories have recommended that minimum level of densities is important to support local services and facilities (Gharpure, 1995; Burdett et al., 2004). But a closer examination of the study areas suggests that despite the adequacy of community facilities in the study areas their number, distribution and scale is not pertinent to the neighborhood scale rather more in conformity to the city scale. From the field, it was observed that the city scale provision of these facilities is, therefore, inviting the city traffic into the neighborhood regularly. As reported by the respondents' severe traffic congestion due to this unwanted traffic is commonplace in these residential areas hindering the accessibility of the local residents to these facilities and amenities in terms of travel time and thereby hampering the quality of life. Most of the inhabitants usually avail these facilities through rickshaw which takes about 10-15 minutes. But due to the frequent traffic congestion, these short trips take exhaustingly more time which is totally unacceptable. So even though having adequate and sometimes over the provision of these community facilities the local residents cannot accrue the full benefit from them. A standard for the provision of community facility is provided in DAP 2010 but no directives have been suggested to implement it. However, it is usually ensured through government land-use policy with community facility planning and their managerial and financial capacity to distribute social infrastructure evenly among various parts of the city. But in absence of such policy, the provision of social infrastructures through private initiatives tends to cross or sometimes overlook the demand of the residential areas. So although the statistical analysis of this research shows a positive relation of density with this sustainability aspect the planning considerations associated with the accessibility of the existing community facilities portray a picture quite contrary to the sustainability requisites.

b) Community Stability and Social Cohesion

The statistical findings indicate that higher density residential areas have a higher number of social interactions but when the building or neighborhood was perceived as crowded then the number of social contacts are fewer. Social cohesion in the community helps to build social capital which helps to resolve most of the community problems by themselves and creates a social safety net for the community. Social cohesion is developed through frequent informal social interaction which helps to cultivate trust and nurtures bonding among the neighbors. The research findings also revealed that the form of traditional bonding is still prevalent in the high-density neighborhoods of Old Dhaka but not very prominent in the neighborhoods of new Dhaka. The cause of this diminishing status of the social capital in the new neighborhoods may not be attributed to the density alone as indicated in the results of correlation analysis. The design of the built environment, as well as the lifestyle of the residents, is identified as important predictors hampering the formation of social capital in contemporary neighborhoods. In the pursuit of an urban lifestyle, city dwellers have to spend a major portion of the day at work and traffic congestion which spares very little time for them to stay at home and socialize with neighbors.

On the contrary, people happen to spend more time with their colleagues rather than their neighbors. This facilitates the formation of social capital through *bridging* is increasingly replacing the *bonding* exercise which used to be a common practice previously in the traditional neighborhoods. Even Globalization can be seen as a *bridging* exercise of social capital. However, some argue that the expansion of social capital in globalization has been done at the expense of traditional *bonding* of social capital, which is based on shared norms, values, and cooperation among in-group members for common ends and this could be partly true in this case. *Bonding* and *bridging* in social capital can co-exist as long as they are in harmony and well-balanced (Putnam, 1998). But as revealed from the field survey results mentioned in Section 3.4 the inhabitants of the residential areas of new Dhaka are found to be more interested in the bridging exercise which tends to form various groups based on similar occupation and shared interests thereby results in a reduced level of social cohesion among their immediate neighbors. Apart from the lifestyle demands the urban design elements such as lack of open space, the design features of the multi-dwelling buildings as well as the street designs do not provide the opportunity for social bonding. Under the circumstances, the bonding exercise is found to be gradually diminishing and being increasingly replaced by bridging and linking exercises. The future consequences of this type of social capital are likely to lead towards centrifugal fragmentation in the

society which is a major threat in developing social sustainability.

c) Sense of safety

The findings of the research found gross population density to be positively associated with the sense of safety which indicates that the higher the density contributes to a higher sense of safety as it was found very prominent in the dense residential areas of old Dhaka with a relatively good degree of social cohesion. While in the new residential areas though people were found satisfied with the sense of safety their security was achieved through the practice of gated communities rather than natural vigilance system provided by the neighbors like old Dhaka. Various researches have recognized the positive impact of social capital on safety issues of the neighborhood. The results from new residential areas indicate though the sense of safety is increased with high density this is not helping in nurturing social bonding where vigilance is formed by the presence of people alone rather than any physical aid. The design of the apartment buildings which does not encourage informal social interaction in their narrow corridors and small balconies could be another reason for this kind of social isolation. This again suggests that built form characteristics, design, and layout associated with lower social capital also contribute to the prevalence of reduced sense of safety and vice versa evident from the findings of the study areas. Thus, it was found that generally higher density had a positive association with a sense of safety but if the area is perceived crowded then the relationship becomes negative. However, crowding within the dwelling was found to have no relationship with indicators of safety.

d) The Health of the Inhabitants

Despite the residents' overall higher satisfaction level regarding the living condition at differing densities, the self-reported health statistics indicate an unfavorable result which questions the livability as well as the sustainability of these residential areas. Besides the overall positive association of high density with health problems the findings also revealed that a higher incidence of stress-related health problems was found common in all the study areas while pollution-related problems were relatively higher in some of the new residential areas. As discussed earlier in section 3.3 the cause of the stress and pollution-related health complications can be traced to the design features of the built environment (amount of living space, lifestyle, lack of outdoor recreation spaces, dwelling design, vehicular emission, etc.) of the residential areas. A growing body of literature indicates that sedentary lifestyles have been increasing in recent decades leading to increased risk of Type II diabetes, cardiovascular disease, obesity, and various cancers. The use of open spaces to promote physical activity is an important part of addressing these conditions in an urban setting. But from the survey, it was found that old Dhaka residential areas are devoid of open spaces while the new residential areas have open spaces but still far below the actual requirement. The shortage of adequate open spaces and especially green spaces, which promote a healthy active lifestyle by providing an accessible, affordable, and enjoyable place to be physically active could be one of the prime causes of higher incidence of stress-related problems in the study areas. Furthermore, the prolonged exposure to the vehicular emission caused by the daily traffic in the neighborhoods can also be responsible for the increased pollution-related health problems of the new Dhaka study areas. Since the built environment features and overall design show a lack of consideration in promoting good health to the inhabitants the sustainability of the community as well as the residential area seems vulnerable.

e) Privacy

Although the observations revealed that the measured intensity of noise was above the residential threshold but the majority of the residents did not recognize it a as problem. Similar responses were also found towards the degree of visual obstruction and loss of privacy caused by closely placed adjacent buildings which were quite high in the study areas. The reason for people's insensitivity towards visual and acoustic privacy could be the lack of awareness regarding the hidden ill effects of these factors on health. Needless to say, if people are left exposed to such unacceptable environmental conditions for a prolonged period then this would certainly impart serious physical and psychological impairment in the future generations putting the overall sustainability of the community at stake.

f) Amount of Living Space

The respondent's amount of living space was also considered in the supplementary measures of urban form. Although the research found that higher density is negatively associated with the amount of living space and affordability of houses, the respondents' attitude towards their dwelling space implied that this variable had only limited significance towards the sustainability of the community. However, the satisfaction level regarding dwelling space does not always rely on its size but the length of stay and the community cohesion which had a significant role to play. Perhaps due to these two factors, the residents of old Dhaka despite living in small dwellings have displayed greater satisfaction in comparison to their counterparts in new Dhaka.

However, in reality, it would be inappropriate to attribute the production of smaller living spaces to high

population density alone. In the context of Dhaka, the Floor Area Ratio (FAR) restrictions, which allows extra height bonus for less ground coverage is one such factor. Due to the application of FAR there is less available built space which naturally reduces the per capita living space. This results in the construction of smaller size apartments which has to compromise with the amount of living space. The application of FAR cannot be beneficial enough unless the occupancy density and amount of living space per person is considered. Besides, the lack of sufficient open space in the neighborhood promotes people to spend more time indoors. Therefore, the indoor space needs to be more spacious to compromise the shortage of open space to some degree. But the private developers' concern is making a profit rather than creating standard living space for the community.

VI. Conclusion

The findings discussed in this study show the consequences of densification based on the empirical study conducted in seven sample wards of Dhaka. On the basis, of results from the analysis, it is evident that there is a wide range of consequences found in the residential study areas of differing densities. The findings reflect that traffic congestion, lack of public transport, lack of open spaces, thus the improper allocation of social infrastructure are the major visible consequences while health problems, social cohesion, and people's lack of awareness regarding social and environmental problems are apparently the silent consequences of densification. The contradictions presented by the arguments in Section 5 signal an emerging urban crisis that questions the sustainability of the residential areas of Dhaka. Marx defines crisis as the manifestation of underlying problems. The emergence of this crisis can be identified through the residents' growing dissent stemming from a host of urban problems both obvious and imperceptible like, lack of open space, lower sense of safety, health complexities, diminishing state of social cohesion in the densifying residential areas of Dhaka. Given the summary findings, it can be said that the underlying problems of this crisis seemed to be deeply rooted in the current process of densification which is posing a threat to the overall social sustainability of the residential areas of Dhaka. Though the current livability condition of the residential areas seems to be passing through more or less a tolerant phase but considering the growing intensity of the urban problems embedded in the very system of the development process itself, the sustainability of these residential areas, in the long run, becomes quite questionable and uncertain. The magnitude of most of these explicit and hidden problems of the dense residential areas seemed to be within the tolerable limit at present which makes them more or less livable for the time being but if this trend of development keeps on continuing then the aggregate outcome of these growing complications will multiply and produce an unbearable situation for the residents in near future. Under such circumstances, the livability of these residential areas will further decline. Overall the studies of this research are suggestive that despite the statistical data showing a more positive result the consequences of densification is likely to have far-reaching negative implications on the sustainablilty of the residential areas in the long run. Hence, from the sustainability perspective, the ongoing trend of densification of the residential areas of Dhaka does not appear to be sustainable at all.

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Higher Education Policies in Brazil: From a Foreign Policy Strategy to the Dismantling

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Keywords: higher education; foreign policy; brazil.

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Marcela Vitarelli Batista [α], Roberta Rodrigues Marques da Silva [σ] & Thais Ferreira Rodrigues [ρ]

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I. Introduction

From 2003 to 2011, Brazil experienced the most remarkable economic growth since its transition to democracy in 1985. The victory of former factory worker Luiz Inácio Lula da Silva from the Worker's Party (PT) in the 2002 presidential elections represented a historic milestone in Brazilian democracy, inaugurating a period marked by economic prosperity and social inclusion. PT governed the country until 2016, when Dilma Rousseff, the first woman elected president in Brazil, was removed from office in a controversial impeachment process (Singer, 2018). The brief but troubled government led by Vice President Michel Temer represented a decisive step away from the previous model, as he pursued a neoliberal agenda. The dismantling of reforms that occurred during the PT years continued with the election of the far-right Jair Bolsonaro as president in late 2018. Elected on the basis of an anti-PT and anti-left discourse, Bolsonaro has sought to undermine the path traced by the previous governments. Such is the political basis that underlies the analysis of higher education policies and education internationalization efforts, which is the subject of this paper.

Higher education policies were also part of the foreign policy agenda, as the PT's governments aimed to increase universities' internationalization through international cooperation and the creation of universities that specifically aimed to promote regional integration. The pluralization of Brazilian foreign policy was a noticeable feature of Lula's agenda, which included diversified policy issues and an increasing number of state and non-state actors (Cason & Power, 2009). Among the new issues on the foreign policy agenda, higher education programs stood out: the emphasis on South-South relations became intertwined with the goal to promote social and economic development. In this sense, amplifying social access to public universities and promoting Science and Technology (S&T) policies - which relied heavily on public universities in Brazil – became a sensitive aspect of the foreign policy agenda.

Brazil shifted from the most dynamic period of educational policies in Lula's period (2002-2010) that remained and were amplified in Rousseff's government (2011-2016) to Bolsonaro's government which has taken the opposite direction. On the one hand, between 2003 and 2016 the PT's governments created 18 universities, 422 technical schools, and 173 new campuses. In this period, 7.1 million young people were admitted to Brazilian universities. On the other hand, Temer's government approved a 30% budget cut for the 63 federal universities under Constitutional amendment n.95/2016. Today, Bolsonaro leads an era of "scientific denialism" and moralism, culminating in a possible loss of countless scientific education and research institutions (Leher, 2019).

The radical changes experienced by the national politics reflected directly on the educational policies. But in what way? The objective of this article is to understand how Brazilian political changes in the analyzed period between 2007 and 2019 affected higher education policies, emphasizing universities' internationalization. Likewise, it aims to identify similarities and differences between four political periods and understand the reason for this dramatic change of direction in Brazilian educational policies.

The article argues that, during the PT's governments, there was a convergence between foreign policy and domestic development goals. The overall goal was to promote development, combining both economic prosperity and welfare policies. The increase of offer in education was inserted in the welfare logic. Particularly, higher education policy was considered key to achieving social inclusion and industrial development, especially in Rousseff's government. At the same time, the educational policies were reflected in the foreign

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policy agenda through international cooperation (BRICS; Mercosur and Unasur), programs such as "Science without Borders", and new universities like UNILA and UNILAB.

II. Methodology

We pursued a comparative analysis, conducting bibliographical research of the most prominent authors in the contemporary domains of Brazilian Political Science, Brazilian Foreign Policy, and Brazilian Political Economy. We analyzed political speeches, official documentation, and the budget data available from the "Portal Transparência" (Transparency Portal) – the government platform dedicated to making all expenditures of the federal government public.

The paper is organized by presidential administrations in the following time sequence: Luiz Inácio Lula da Silva second term[1] (2007-2010), Dilma Rousseff (2011-2016), Michel Temer (2016-2018), and Jair Messias Bolsonaro (2019-). First, we conduct an analysis of the foreign policy matrix[2] as it is essential to understand the central role of education in certain foreign policy periods, specifically, Lula da Silva and Dima Rousseff. We also highlight how this relationship was broken during later governments. Finally, we highlight the most important public education policies associated with each government. The result is a broad comparative table detailing policy in every studied period.

We argue that, during the PT's governments, educational policies were a priority and, more importantly, a part of the foreign policy agenda. On the other hand, during Michel Temer's and Jair M. Bolsonaro's governments, the education sector suffered budget cuts and lost its importance. Therefore, a progressive dismantling of higher education policies in Brazil is evident, with a particular impact on the internationalization of the country's universities.

a) Luiz Inácio Lula da Silva (2007-2010): a step forward

i. *Autonomy, multilateralism, and South-South cooperation*

The idea of becoming an international and regional power is historically rooted in Brazil's political agenda. According to Soares Lima and Hirst (2010: 21), "*since the early years of the twentieth century, Brazil´s major foreign policy aspiration has been to achieve international recognition in accordance with its belief that it should assume its ´natural´ role as a ´big country´ in the world affairs*". Therefore, since its military period (1964-1985), Brazil aimed to consolidate its role as a new economic power, but it was only during the 1990s, through Mercosur, that an effort was made to establish macroeconomic openness and regional integration. From 2002, Lula da Silva's active foreign policy, taking advantage of a favorable external economic situation, achieved a large part of these leadership ideals.

Under the command of a diplomat Celso Amorim, foreign policy was defined by the search for autonomy, increasing the Brazilian presence as a global actor based on the logic of multilateralism through South-South strategic relations. The focus on South American and Latin American relations was clearly mentioned in Lula's inaugural speech:

> "The highest priority of the foreign policy in my government will be the construction of a politically stable, prosperous and united South America based on democratic ideals and social justice. For this, a decisive action to revitalize Mercosur is essential, [as it has been] weakened by the crises of each of its members and often by narrow and selfish views of the meaning of integration. [...] We will deepen relations with major developing nations: China, India, Russia, South Africa, among others" (FOLHA DE SÃO PAULO, 2003)

In the context of the "autonomy for diversification" strategy (Vigevani and Cepaluni 2011), Brazil sought the reduction of economic asymmetries with world powers, forming alliances with developing countries, non-traditional partners, and regional alliances, as well as prioritizing South-South cooperation. Therefore, Brazil pursued more balanced gains among parties, avoiding a hierarchy of domination common in the Northern countries. Unasur was conceived as an institution with strong guidelines, focusing in particular on regional defense, developmentalism, and democracy. Largely created as a result of the Brazilian geopolitical design, Unasur reflected Brazil's search for autonomy and its willingness to become a regional and global player (Sanahuja, 2012).

The creation of BRICS in 2009 is also worth mentioning for the purposes of this argument. By the end of its first summit in Russia, the group released the joint statement of the BRIC countries' leaders. The document, endorsed by Brazil, Russia, India, and China, attempted to promote the G20 summit's decisions in dealing with the financial crisis of 2008, fostering cooperation, policy coordination, and political dialogue. The second BRIC summit held in Brazil underlined the countries' "support for a multipolar, equitable and democratic world based on international law, equality, mutual respect, cooperation, coordinated action and collective decision making of all States" (2nd BRIC Summit – Joint Statement, 2010). Due to the important differences of the member countries and the non-binding legal character of decisions, the bloc has had limited scope since the beginning (Stuenkel, 2017). Aligned with the universalist and autonomist characteristics of Lula's foreign policy, the BRIC group was a counterbalancing attempt to promote new power alliances based on non-occidental cooperation.

The emphasis on South-South cooperation paved the way to the pluralization of foreign policy topics. Middle-income countries face similar

development-related challenges in a multiplicity of policy areas, such as education. In this sense, the welfare policies implemented by Lula's government domestically would soon be considered fundamental to the building of strong international leadership. Brazil obtained unprecedented prestige in the international arena, emphasized by the defense of sovereignty and national interests (Louback, 2016). South-South cooperation flourished around central developmental policies, including policies on higher education.

ii. *Educational Public Policies: strong steps*

The Brazilian higher education landscape is characterized by an imbalance in the system, with a high percentage of underqualified private universities and, for a long time, a dubious student selection system in public universities. According to Benincá and Pereira (2016), "*the Brazilian university, like all of Latin America, has always been based on meritocratic and individualistic criteria, which disregard social stratification and antagonistic structural conditions*". Therefore, the main challenges are, on the one hand, the universalization and democratization of access to higher education, and on the other hand, the improvement of quality and internationalization. That said, the most dynamic period for Brazilian higher education since the 1985 democratization occurred during Lula's rule. His government focused on the expansion of public institutions. Public policies were designed to expand and geographically internalize[3] higher education, as well as to promote the inclusion of socially, ethnically, and territorially marginalized students. Brazil, "*an incomplete elementary education country, started to conceive that the historically marginalized population could partially be seen on university desks*" (Martinez, 2018: 6).

According to Almeida de Carvalho (2014):

> "…the difficulties of the poorest social class in accessing this [higher] educational level and, although the barriers to entry could be overcome, the government's perception that the main challenge was the permanence of those socially vulnerable student in the face of high spending in private establishments. (…) Lula's] governmental agenda was redirected in order to significantly increase [the number of] places at public universities, especially in the federal segment".

The Program of Support for Restructuring Plans and Expansion of Brazilian Federal Universities (REUNI – *Programa de Apoio a Planos de Reestruturação e Expansão das Universidades Federais)*[4], instituted by decree no 6.096 of 24th April 2007, relied on the strategic role of the universities, especially the public ones, in promoting economic and social development. The policy had as its starting point the assessment that "the net education rate of Brazilian higher education was very low and far from the target of 30%[5] proposed by the National Education Plan (PNE 2001-2010)" (Almeida de Carvalho, 2014).

The expansion of the Federal Higher Education Network began in 2003 with the interiorization of federal university campuses. Thus, the number of cities with federal universities increased from 114 in 2003 to 237 by the end of 2011. The universities created had *multicampi* structures and, not infrequently, were installed in municipalities that had never before hosted higher education institutions (Brackmann 2010; Martinez, 2018).

In his inauguration ceremony, Lula da Silva affirmed: "*We managed to take federal universities and professional education schools from the capitals to the inland*" (Lula da Silva 2010[6]). On the same day, Fernando Haddad, then Minister of Education, concluded that the expansion of the federal network changed the life of the Brazilian people, saying that "the population now understands the true meaning of education, which is the emancipation of the individual".

From 1909[7] to 2002, 140 federal technical schools were created in Brazil. After the implementation of REUNI, 342 new institutions were established. Fourteen new federal universities were created between 2003 and 2010 with the purpose to interiorize public higher education. Other four–University for International Integration of the Afro-Brazilian Lusophony (UNILAB), Federal University of Western Pará (UFOPA), Federal University of Latin American Integration (UNILA), and Federal University of Southern Border (UFFS) – were planned for the regional and international integration (MEC, 2010[8]). These new universities were strategically disposed across the national territory from the Amazon region to southern Brazil. Two of these universities were given an international vocation and specific mission – the Federal University for the Integration of Afro-Brazilian Lusophony (UNILAB) based in Redenção, in Ceará, and the Federal University for Latin American Integration (UNILA) in Foz do Iguaçu, Paraná. Between 2007 and 2012, the restructuring expansion occurred, increasing the numbers of student places in 59 universities. Also, in the same period, the number of enrollments in HEIs grow 46%.

The REUNI also guaranteed financial support for the growth of the number of places, existing courses, or new courses. In return, universities should improve their performance indicators, such as student/teacher ratio, as well as dropout and enrollment rates (Trombini et al 2020). In the period between 2003 and 2011, there was an increase of 111 % in the offer of places in on-campus undergraduate courses in federal institutions. The growth of 91,655 places in the period from 2007 to 2011, going from 139,875 places in 2007 to 231,530 in 2011 (Trombini et al 2020), is particularly noteworthy.

The creation of new universities materialized in the direction of the foreign policy adopted by Amorim, fulfilling an important role in accomplishing the objective of promoting regional integration. In Lula da Silva's government, the African coastal countries were placed

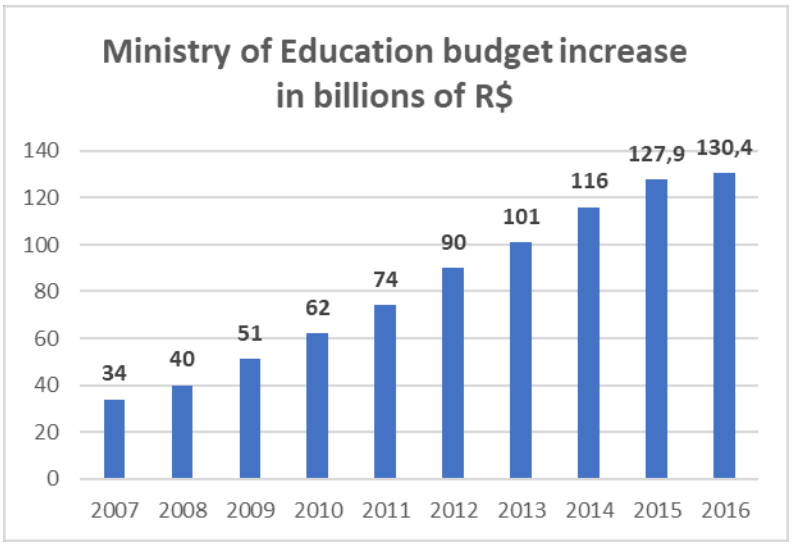
among South-South strategic priorities (Almeida, 2015). UNILAB had the mission to promote human resources to contribute to integration between Brazil and other member countries of the Community of Portuguese-Speaking Countries, especially in Africa, including Angola, Cape Verde, Guinea-Bissau, Mozambique, St Thomas and Prince, as well as Portugal and East Timor. UNILAB proposes to promote regional development and cultural, scientific, and educational exchange.

UNILA, created in 2010 had the mission to establish a clear relationship between the university and Mercosur, as well as with the Latin American integration project. At the moment of its foundation, it aimed to create 10,000 places for undergraduate and graduate students from Brazil and the neighboring countries (Almeida, 2015; Brackmann 2010).

Along with the growing number of public universities, Lula's government also aimed to promote social inclusion by facilitating access and permanence in the universities. In order to achieve the first goal, the Unified Selection System (SiSU – Sistema de Seleção Unificada) was established, allowing students to apply to institutions in various states of the country only using the National High School Exam (ENEM)[9] score. This way, SiSU allowed an increase in the center-periphery flow and the democratization of higher education in Brazil. It gave more options of the universities to apply to a larger group of students with a range of financial backgrounds from small and medium cities. As a result, the number of students enrolled in public universities jumped from 3 million in 2005 to 5,5 million in 2011[10].

In addition to access, universities were also able to expand their actions aimed at the permanence of students. The resources of the National Student Assistance Plan (PNAES), created in 2007, increased from R$125 million (USD 23.1 million) in 2008 to R$304 million (USD 56.2 million) in 2010. With this plan, universities developed their assistance programs by financing various items of expenditure for their students, such as health, transportation, housing, and food. The Ministry of Education's resources for professional education also grew from R$1.2 billion (USD 220 million) to R$4.9 billion (USD 910 million) in the same period.

Financing of the expansion of public universities was possible because of an increase of the Ministry of Education budget, which can be seen in the diagram below:



Elaborated by authors, source Trombini et al 2020.

Diagram 01: The expansion of budget from the Ministry of Education

Though the expansion of public universities was substantial, finishing the narrative at this point would tell only part of the story. The private higher education system also experienced a massive expansion during Lula's government. Historically, private universities constitute most of the offer in the country's higher education. In 2007, two-thirds of Brazilian students were enrolled in private institutions (Marques, 2018). In 2017, there were 296 public institutions, against 2,152 private ones.

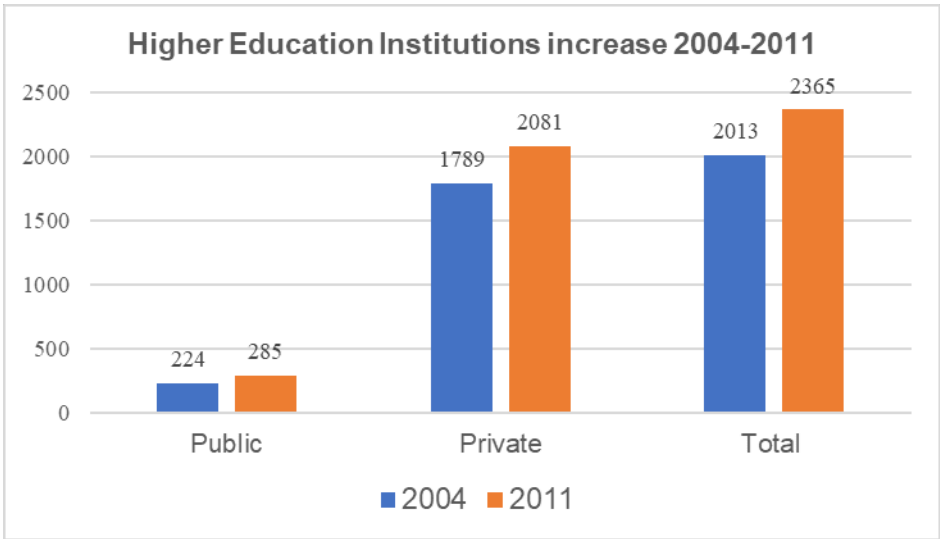
Lula boosted private higher education institutions through public financing of student debt. He reformed the Higher Education Student Financing Fund program (*FIES - Fundo de Financiamento ao Estudante do Ensino Superior*), created by his predecessor, Fernando Henrique Cardoso. Furthermore, his government established the program "University for All" (ProUni), created in 2004 and made official by Law no. 11.096 in January 2005. ProUni granted partial and full scholarships (covering 25% or 50% of the fees) to students in technical degrees and specific training and programmes in private higher education institutions, in return offering tax exemption to the institutions that joined the Program (ProUni[11], Silveira, 2011). ProUni

focused on "Brazilians who do not hold higher education degrees, whose monthly income per family does not exceed the value of up to 1 (one) minimum wage and 1/2 (half)" (Brasil, 2005[12]). In this sense, the program aimed to expedite the inclusion of socially neglected students in private institutions (INEP, 2017)[13].

In 2008, by Law no. 11.892, Lula's government created the Federal Network for Professional, Scientific and Technological Education[14]. As ambitious as REUNI, the Federal Network was aimed at the expansion and geographical internalization of professional federal institutions. These higher education institutes provide technical-level qualifications and several basic-level courses in the industry and service areas. The expansion of the education system during the PT's government was outstanding: there were created 38 federal institutes, two new Federal Technological Education Centers (CEFET), the Federal Technological University of Paraná (UTFPR), 22 technical schools linked to federal universities, and the Colégio Pedro II high school.

According to Marques (2018:2), the expansion of the higher education network was outstanding. In 1996 there were 922 higher education institutions (HEIs), 211 of which were public (23%) and 711 private (77%), with a total of 1,868,529 students enrolled. In 2005, the total number of HEIs rose to 2,165 with 231 public (10.7%) and 1,934 private (89.3%) institutions. In the same year, the ratio was the following: from a total of 4,453,156 students, 1,192,189 (26.77%) were in the public sphere and 3,260,967 (73.23%) in the private sphere. In 2011 (the first year of Rousseff term), there were 284 public HEIs and 2,081 private ones, a legacy left by the Lula administration. Finally, there was a total of 6,739,689 students enrolled in private and public institutions.

Below, we present a diagram showing the increase of HEIs during Lula's government:



Source: Elaborated by author, Marques 2018.

Diagram 2.0: The expansion of the higher education institutions during Lula's government

However, the expansion of higher education was not exempt from criticism. On the one hand, critics highlighted the fact that the REUNI allowed hiring of a limited number of teachers and technical-administrative personnel, which was below the necessities. On the other hand, in the private sector, higher educational institutions, notably smaller ones, lacked systematic research, which might have put its graduates at a competitive disadvantage in the job market (Louback, 2016:62). Silva (2017:9) calls the expansion of private higher education a "*fast delivery diploma*" with the objective of "*increasing public education through distance learning programs*".

In summary, during Lula's period, higher education was a tool to promote foreign policy, especially regional integration, as well as a drive to promote social programs. Lula ended his government with one of the highest popular approval rates in Brazilian democratic history, estimated at 87%[15]. Unlike other governments in the region, like Bolivia and Venezuela, despite his popularity, Lula knew how to respect democracy and the alternation of power. Lulism ended with the transfer of Lula's political support leading to the election of his successor, President Dilma Rousseff.

b) Dilma Rousseff (2011-2014/ 2016): restraint in continuity

i. *Rousseff's Foreign Policy*

The foreign policy in Rousseff's government followed the same matrix as did Lula da Silva's government. Still, there were some adjustments based on the management style and the changing international environment. Antonio de Aguiar Patriota (Chancellor

from January 2011 to August 2013) maintained the same government objectives as Lula da Silva: development through the diversification of commercial partners in the South-South model and the affirmation of Brazil as a global actor. South America was kept as a priority on the Brazilian external agenda. However, the persistence of the international economic crisis and political instability were defining factors in constraining Brazil's actions and limiting its international leadership (Bastos & Hiratuka, 2020).

Some authors suggest that Rousseff's foreign policy was different from Lula's since she was less active (Cornetet, 2014). Others believe Rousseff's administrative profile and view of international politics was not the same in terms of the international projection of Brazil in comparison to that of Lula. Moreover, it is mentioned by some critics that she prioritized internal politics over external (Stuenkel, 2017; Cornetet 2014; Louback, 2016).

Nevertheless, it was during Rousseff's government that several cooperation projects expanded and flourished. Rousseff reinforced integration projects such as Mercosur (supporting the suspension of Paraguay after the institutional coup against Fernando Lugo in 2012 and Venezuela's accession to the bloc), Unasur, CELAC and BRICS. In 2011, the BRIC group incorporated South Africa. Now BRICS, the bloc gained a global approach, including the African continent. The economic cooperation was reinforced by the creation of the BRICS Investment Bank. With the capital of USD 50 billion, the bank would promote strategic action in several areas including higher education research.

According to Muhr and Azevedo (2019), education was mentioned twice in the BRICS annual summit statements: in 2009 and 2013. Nevertheless, the intra-BRICS educational cooperation developed after the first meeting of the BRICS Education Ministers in Paris in November 2013. This meeting happened at the 37th session of the UNESCO General Conference. The BRICS' agenda sought to highlight the relevance of education as an imperative dimension in South-South cooperation. The objectives were directed toward "*inclusive and equitable quality education*" and "*lifelong learning opportunities for all*"; moreover, education was a "*political project for emancipation, liberation, and a political-economic independence*" (Muhr and Azevedo, 2019).

Though Rousseff kept a low profile in foreign policy, it is noteworthy that her government not only maintained Lula's foreign policy agenda focus on development and welfare promotion but also highlighted education as a central policy issue. If Lula had inaugurated the pluralization of foreign policy agenda and the pursuit of social inclusion in the domestic arena, it was Rousseff government that promoted the marriage between foreign policy and higher education.

ii. *Expansion and Continuity in Education*

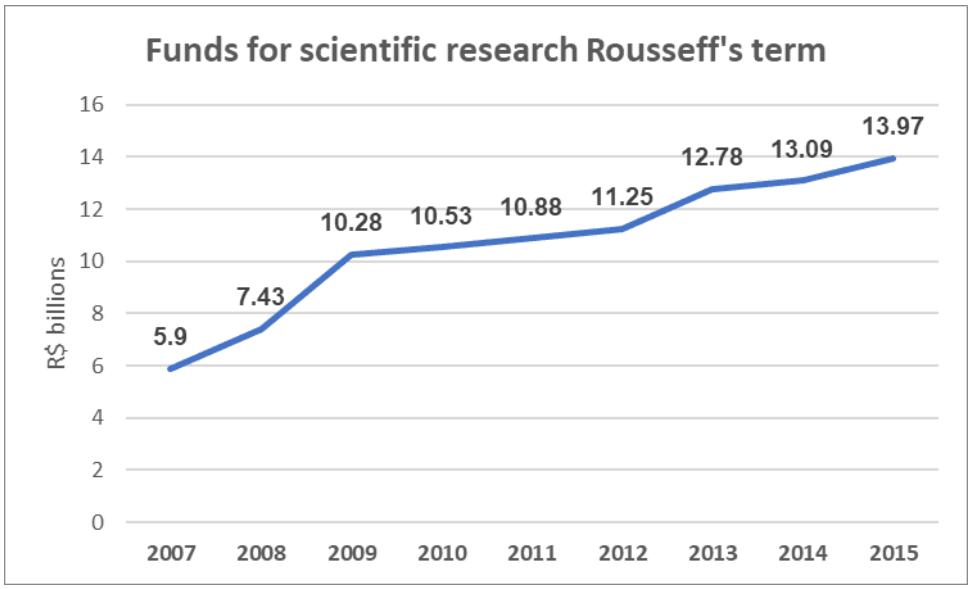
Rousseff continued Lula's project of higher education expansion, aiming to increase the number of universities, remove barriers to the entry of marginalized students, and promote higher education institutions' internationalization.

During her government, four new federal universities were created in the poorest North and Northeast regions, in areas with no public higher education institutions: UFESBA and UFOB in the south and west of Bahia; UFCA in Ceará, and the *multi-campi* UNIFESSPA, covering the south and southeast regions of Pará.

Beyond expanding the number of student places in public universities, Rousseff sought to reduce social and ethnic asymmetries in the entry of new students. During her first term, important Law no. 12,711/2012 known as the "Quotas Act" was approved. It was a historical reparation in a deeply unequal country ruled by the decimation of indigenous people since the colonization process. Brazil was the country that received the largest number of enslaved blacks in the world, 4.9 million people, and the last country in the West to abolish slavery. This law determined that federal higher education institutions linked to the Ministry of Education must reserve, in each selective contest for entry into undergraduate courses, at least 50% of their vacancies for students who attended public high schools. The places must be filled by self-declared people of color and indigenous people, as well as by people with disabilities.

After the abolition of formal slavery, no public policies were planned for the newly freed black population to be incorporated as citizens into the society in a dignified manner. As a result of racism which became structural, the black population had lower access to education. Over a century behind, the quota law fulfilled the role of promoting equitable access to opportunities through higher education. Data from IBGE (National Statistics Bureau) show the chance of getting a degree has increased almost by four times among the black population in the country. Since the first experiences of affirmative action in higher education, the percentage of black Brazilians who graduated from universities grew from 2.2% in 2000 to 9.3% in 2017. Although inequalities are still significant, this public policy has a transformative potential, which can be seen from the data released by the National Association of Directors of Federal Institutions of Higher Education (Andifes). The study reveals that, for the first time in the history of Brazil, there are more non-white (51.2%) than white students in higher education institutions. In this group, 64.7% attended public high school and 70.2% came from families with monthly per capita income of up to 1.5 minimum wages (Ribeiro, 2019: 22-25).

Rousseff government also pursued an expansion in S&T. On the one hand, it is worth noting the expansion in financing provided to the National System of S&T, comprised by the Ministry of Science, Technology and Innovation (MCTI), the National Council for Scientific and Technological Development (CNPq), Coordination for the Improvement of Higher Education Personnel (CAPES) and Funding Authority for Studies and Projects (Finep).



Source: Sociedade Brasileira para o progresso da Ciência

Diagram 03: Funds on scientific research during Rousseff's period

On the other hand, research and training were boosted by "Science without Borders" (*Ciência sem Fronteiras*), possibly the most ambitious program in the internationalization of higher education in Brazil. Science without Borders was created by the Decree nº 7642 of 13th of December 2011 (Aveiro, 2014:17). This international academic mobility program aimed to promote innovation, modernization, competitiveness, and international insertion through the technical-scientific training of young Brazilians in high-ranking international universities (Muller 2013:47). At the same time, the program supported the attraction of recent PhD graduates and senior international researchers to Brazil. The rationale behind the program is the potential to produce a significant impact on the Brazilian industry, the sector in which most of these professionals would be integrated.

The project covered four main areas of knowledge, with four types of scholarships: sandwich degree (SWG), postgraduate and postdoctoral studies, the attraction of young scientists to Brazil, as well as professional and technological education. Scholarships for undergraduate students were prioritized, which was an innovation in higher education policies in Brazil; until then, the focus had always been on graduate studies. According to Sehnem (2019), Rousseff had personal involvement with the program, which seemed to raise its status and guaranteed resources for its execution (Sehnem, 2019). Of 101,446 scholarships awarded in the period, 78% (78,980) were for the Sandwich Graduate Program (SWG), with an investment contribution of almost R$10.5 billion (CAPES e CNPq, 2016).

Initially, the program was aimed at the U.S. universities, similar to Barack Obama administration's plan "100,000 Strong in the Americas"[16]. Two international cooperation agreements were signed between the U.S. and Brazil in a short period of time in 2011. Faced with the difficulty of accomplishing this in a limited amount of time, there was the decision to expand the partnerships with approximately 30 countries (Prolo and Vieira, 2017).

However, the project attracted criticism. Schwartzman (2015:35) pointed out that "the universities were forced to expand without enough resources and preparation and could not cope with the new inflow of students and professors hired with working conditions that do not match with the previous standards". In addition, the program sent students and researchers mainly to English-speaking countries in the regions like the United States and Europe.

The impetus towards building both a socially inclusive project and strong South-South cooperation around shared development goals – including higher education policies – came to an end in 2016 when the PT, Rousseff's and Lula's political party, was involved in a corruption scandal. Former president Lula himself faced charges. Furthermore, an economic recession started. Facing severe economic constraints and increasing political isolation, Rousseff was removed

from office on 31 August 2016, as a result of an impeachment process[17]. Her successor, Vice President Michel Temer, facilitated a U-turn in the policy agenda, aiming to promote radical neoliberal policies with profound impacts on higher education.

c) Michel Temer (2016-2018): beginning of dismantling

The vice president of Dilma Rousseff assumed the presidency on 31 August 2016. Not only the national politics were in disarray, but the international context of this period was also somehow unstable. The election of Donald Trump in the United States and Brexit in Europe further contributed to this scenario. In South America, the so-called "pink tide" period ended with the Paraguayan coup against Fernando Lugo, as well as the election of Mauricio Macri in Argentina, Sebastian Piñera in Chile, and Pedro Kuczynski in Peru (Pereira, 2015).

In Brazil, Jose Serra was appointed chancellor, promising a disruption with the previous governments. Serra, who was not a diplomat but a politician, proposed 10 action guidelines[18], in which he criticized what he called diplomacy based on "ideological conveniences of a political party and of its foreign allies". Serra left office in March 2017 and, despite the plans, none of his projects ended up being implemented.

After Serra resigned, Aloysio Nunes, also a politician, assumed the ministry. He defined a more pragmatic approach to Mercosur, aiming to promote the "deideologization" of relations with Venezuela. Nunes also pursued a new pattern of relations with the United States, negotiating the use of the military base Alcântara in the Northeast by the American army. Through several official lines of communication, the Brazilian Ministry of Foreign Affairs criticized Latin American countries that supported Rousseff in the impeachment trial[19]. The most notorious case was the relationship with Venezuela. Not only the commercial exchange dropped considerably but also Venezuela was suspended from the Mercosur. Furthermore, the readmission of Bolivia to the group stagnated as a result (Costa Silva, 2019).

In the domestic realm, Temer prioritized the discussion of the unpopular economic reforms. In December 2016 – only four months after Rousseff impeachment – Congress approved Constitutional Amendment no. 55, which significantly compromised the financing of public policies offered by the government, among them, education. Amendment to the Constitution no. 95/2016, thus, instituted a New Fiscal Regime, which would be in place for 20 years. It established for each fiscal year an individual limit for primary expenses of the Executive Power, equivalent to the primary expense paid in the fiscal year 2016. It included the remains to be paid and other operations that affect the primary result, corrected by the variation of inflation the National Wide Consumer Price Index - IPCA. For Carvalho (2018), the approval of this amendment represents the dismantling of Brazilian social policies inspired by the European welfare states through the suffocation of their financing.

Indeed, it is estimated that the education field will lose R$45 billion (USD 8.3 billion[20]) by 2025 with the Stability and Growth Program 241 (PEC 241). The freeze is to make several goals of the National Education Plan (PNE) unfeasible. It should be noted that the successive cuts in education funds have already been happening since 2014 and, with the approval of the Constitutional Amendment no. 95/2016, the situation has worsened. In a Technical Report of the Assembly (2019), regarding the primary expenses paid between 2014 and 2018 by the Ministry of Education and the impact the amendment has been already causing, it was noted that the investment in education in Brazil fell by 56% over four years. Between 2014 and 2018, it decreased from R$11.3 billion (USD 20.8 billion) to R$4.9 billion (USD 9 billion). There was a drop in the amount spent on the three levels of education – basic, technical and higher –, according to a survey based on the budgets realized in the period and corrected by the IPCA. As a whole, the portfolio budget was reduced by 11.7% between 2014 and 2018, from R$117.3 billion (USD 21.6 billion) to R$103.5 billion (USD 19.1 billion).

Regarding the expenses for higher education, there was a drop of 15%, from R$39.2 billion (USD 7.3 billion) in 2014 to R$33.4 billion (USD 6.2 billion) in 2018[21]. Most of the resources that were available were used for compulsory expenditure, including personnel and social security charges. In this period, this expense grew by 11.4% from R$48.8 billion (USD 9 billion) to R$54.4 billion (USD 10.1 billion). If we consider the 2018 budget, in practice, for every R$100, the government spent R$4.70 on investments and R$52.50 on employees and maintenance. The remaining amount, R$42.80, was used to pay current expenses (mandatory and discretionary) – in other words, the funding expenses and expenses on various services to maintain the university structures (cleaning services, water, electricity, etc.), as well as student assistance, fundamental to their permanence in the universities (City Hall Newsletter, 2019[22]).

The proposal and subsequent approval of the AC 55 generated several protests and strikes in federal universities against budget cuts. Some critical intellectuals also began to be persecuted by the Education Ministry and the Judiciary that prohibited activities that debated the coup and its consequences. In 2018, political scientist Luis Felipe Miguel, a professor at the University of Brasilia, offered the course "The coup of 2016 and the future of democracy in Brazil," as a result facing hostility from Education Minister Mendonça Filho. Mendonça Filho publicly declared his intention to appeal to the Public Ministry on preventing the course from being taught but stopped after backlashing due to the negative repercussions the case

took. Sectors of the media and academia accused the government of promoting censorship, a practice largely adopted by the Military Regime in Brazil (1964-1984). In solidarity, more than 10 universities in several states included the course in their programmes.

In spite of the financing cuts, Temer inaugurated five federal universities, which had been planned by Rousseff: Federal University of Jataí (UFJ), Federal University of Catalão (UFCAT), Federal University of Agreste de Pernambuco (UFAPE), Federal University of Rondonópolis (UFR), and Federal University of Delta do Parnaíba (UFDPar). However, Temer promoted setbacks in priorities of Rousseff's agenda. Science without Borders, in the form of an undergraduate interchange program, ended in 2017. The justification behind the decision was the high cost of keeping students out of the country at a time when higher education was undergoing several budget cuts.

d) Jair Messias Bolsonaro (2019-2020)

i. *Bolsonaro's foreign policy: matrix loss*

The Brazilian context in 2018 was defined by great polarization against the PT. Jair M. Bolsonaro, considered an outsider, despite his long political career as a deputy, infamous for his racist, misogynist, and pro-dictatorship rhetoric, was elected president of Brazil with 55% of valid votes. Bolsonaro was elected in the context of an international wave marked by the election of far-right and populist representatives for the executive posts, including American President Donald Trump as the most prominent case.

In his inauguration speech, Bolsonaro affirmed: "we are going to remove the ideological bias from our international relations. We are looking for a new time for Brazil and for Brazilians!" (BRASIL, 2019[23]). His chosen Minister of Foreign Affairs was Ernesto Henrique Fraga Araújo, a career diplomat who, distancing himself from his counterparts, expressed conservative ideas towards what he called "globalism" and demonstrated his admiration to the United States and the ideals of Trumpism. Araújo stated in his inauguration speech that the aim of his government was to "recover the role of the Foreign Ministry as guardian of the Brazilian truth and memory. (…) Brazil will not ask permission from the 'global order' to do whatever it takes to achieve its goals[24]."

Bolsonaro holds a revisionist agenda aimed at removing the legacies of the progressists' governments. In foreign policy, his government rejects the international order and its rules, as well as the advances achieved by minorities in different countries. According to Rodrigues (2019), this is one of the greatest U-turns in Brazilian foreign policy since the military regime, configuring a loss of status in one of the best organized, stable, predictable, and respected areas of the Brazilian state. A country that cared for sociability through diplomacy and international law, started aligning itself with the policy of constant international crisis. President Bolsonaro, called by North American newspapers "Trump of the Tropics", has pushed the country into a pivotal state for the ultra-right in Latin America, putting in question the whole legacy of the Brazilian leadership in the regional and global contexts (Rodrigues, 2019: 1-8). Authors such as Fuser (2019) and Spektor (2019), have already defined the changes that occurred as "subservience diplomacy" and "rupture diplomacy".

In his first year in office, Bolsonaro supported the creation of the Forum for the Progress and Integration of South America (PROSUR). The initiative was launched in March 2019 at the meeting of the South American presidents in Santiago, Chile. This mechanism was designed as a model for regional dialogue to strengthen relations and cooperation among South American states. In September of the same year, during the UN General Assembly in New York, the operating guidelines were defined by the foreign ministers of Argentina, Brazil, Chile, Colombia, Ecuador, Peru and Paraguay. In the released document, the areas of infrastructure, energy, health, defense, security, and fighting crime and disasters were listed as key policy issues. Education was absent. A brief mention of the need for access to quality education can be found in the sessions of the event dedicated to objectives, however, no discussion took place.

The creation of the PROSUR, with the exclusion of several countries in the region, and the loss of space for education in the integration priorities points, in principle, to the dismantling of Unasur and an alignment of the presidents identified in a right-wing political spectrum in the reorganization of policy priorities among public authorities in the region.

Against the Brazilian customary diplomatic tradition, in 2019, Bolsonaro declared, before the elections, his support to Mauricio Macri in Argentina. He affirmed that Argentina could become "the new Venezuela[25]". With the victory of Macri's opponent Alberto Fernandez, Bolsonaro declared that the Argentinians "did not choose well". There was a radical change in the foreign policy agenda that might have affected not only the bilateral relationship but Mercosur as a whole together with other regional arenas.

We can affirm that there is a matrix loss in the foreign policy, involving the reputation crisis due to the change in foreign policy and the conduct of the president of the republic.

ii. *Educational Policies: the denialism setback*

The political moment for Brazilian education is being defined mostly by the draconian budget cuts and the symbolic aggression against its communities and academic institutions. Since the beginning of 2019, the Ministry of Education have blocked around R$6 billion (USD 1.1 million) under contingency policies which, followed by other ministries, have been submitted.

Approximately a third of this amount – around R$2.2 billion (USD 410 million) – is linked to the budget for the federal universities. Year by year, the government measures are reducing what equates to 0.8% of the GDP from the public spends with social policies and public investments. At the same time, movements for weakening the autonomy of the universities, disrespecting their administrative elections of their directors and deans, seem like the tip of the iceberg of the government's true intentions.

Indicated by Olavo de Carvalho[26], the first person to assume the Ministry of Education's post was Colombian-born Ricardo Vélez Rodríguez. During his short time as minister, his speeches and ideas have dazed and worried the whole of the academic field. Despite being a professor, his first measure in the ministry would be to rewrite history books. In his words, the military coup in 1964, was a "civic moment": "*There was an institutional change, not a coup against the Constitution at the time*". Speaking about the universities, he said that *"they should be reserved for an intellectual elite"*. In addition to praising Pablo Escobar for his civic actions in Colombia, the MEC sent a note to schools asking for the children to be in a military formation to sing the National Anthem and for that action to be recorded. Further, it was requested that Bolsonaro's campaign slogan "Brazil above everything, God above all the people" was read during the event at schools (Leher, 2019).

After a short period, Vélez Rodríguez was dismissed. The new minister, Abraham Weintraub, in his inauguration speech, sustained that he would fight against "cultural Marxism" in the universities, showing his alignment with the presidential family's ideology. His bolsonarist argumentation was absurd, using simplistic denominations, which could be compared to a generalization stating that everyone from the political left are communists.

Right before his inauguration, Bolsonaro criticized what he called "the Marxist junk" in schools, announcing that one of his goals would be to remove any trace of Marxism from Brazilian education. He also accused the university community of allowing certain sexual behavior, not compatible with the Christian morality, more specifically, the Pentecostal and evangelical morality. The new minister Weintraub followed the exact same guidelines. According to Leher (2019), his argumentation to disqualify the universities had two main points: the ideological criticism regarding the existence of "cultural Marxism", and the accusation of Brazilian public universities being a high cost to the people and still not being known as institutions of excellence, which equals to not figuring on the rank of the100 best universities in the world. According to the minister, the federal universities promoted "shambles" and political events, as well as immoral parties.

During the election campaign, some of the electoral judges supported the removal of anti-fascist posters and banners and the interruption of classes that included any electoral debate in several federal universities' campuses. On 31 October 2018, the Brazilian Supreme Court decided unanimously against the police intervention in the universities in favor of the Constitution and of the fundamental rights established by it, including the freedom of professorship, freedom of thought, and freedom of speech. The scientific denialism of the government can be seen in the changes in different bodies and national agency, including the IBGE, the Brazilian Institution for the Environment and Renewable Natural Resources (Ibama), the Chico Mendes Institute for Conservation and Biodiversity (ICMBio), the Economic Defense Administration Council (Cade); The National Institute of Spacial Investigations (INPE), the Finep, The CNPq, the Capes, the universities; and the Federal Education and Technology Institutes, linked to the Ministry of Science, Technology, Innovation and Communication (MCTIC) (Leher, 2019:15).

Refusing scientific evidence, Bolsonaro's leaders intended to deny the reality. Brazil could become a country conceived by cults and for capitalists avid to expand their frontiers and to scale their businesses. This group supports the extraction of ore in indigenous territories, promoting fires in the Amazon to clean the path for pasture, disrespecting workers' rights to a level analogue to slavery, or even deviating money from social security to banks and investment funds.

University autonomy, guaranteed by the 1988 Brazilian Constitution, has been threatened by the presidential decrees. The Decree no. 9.794, from 15 May 2019, established that the appointment of the main positions for the direction of the Federal University should be preceded by an analysis of the names by the Federal Government, creating the Integrated System of Appointments and Consultations:

> *"The acts of appointment, designation, exoneration and dismissal related to commissioned positions and functions of trust of a federal institution of basic education and higher education, of a federal center of technological education, of a federal technical school and of a federal agrotechnical school shall be carried out as the rules of the institution, except for the position of top manager of the institution and holder of a legal organ of the Federal Attorney General's office installed at the institution[27]."*

In June 2019, minister Weintraub launched a program called "Future-se", the objective of which "is to promote a major financial autonomy to universities and federal institutes through incentives to private fundraising and to entrepreneurship" (MEC, 2020), discharging the government from funding the public institutions. The program was for voluntary accession, which means that only universities and federal institutes interested in participating would be included. Besides

this program, the ministry also suggested the introduction of monthly tuition for postgraduation *stricto sensu*, which is currently free and pointed out that the option for the expansion of Brazilian higher education is private education, controlled by the investment funds.

One of the democratic disruptions under Bolsonaro's administration was the failure to comply with the rector's elections by the academic communities through triple lists. It was customary to abide by the choice of the academic community since it is a name chosen within the institutions by electoral rules, considered fundamental for the university's autonomy. However, Bolsonaro, until the beginning of 2021, chose a different candidate in 40% of the cases. Out of 34, he nominated 15 who were in the 2nd or 3rd positions in the electoral colleges' disputes.

Although not illegal, this recurring attitude of Bolsonaro is criticized for weakening universities' mechanisms of participation and guaranteeing plurality, seen as a controlling method of federal institutions and a violation of the principles of university autonomy, impersonality, and public morality.

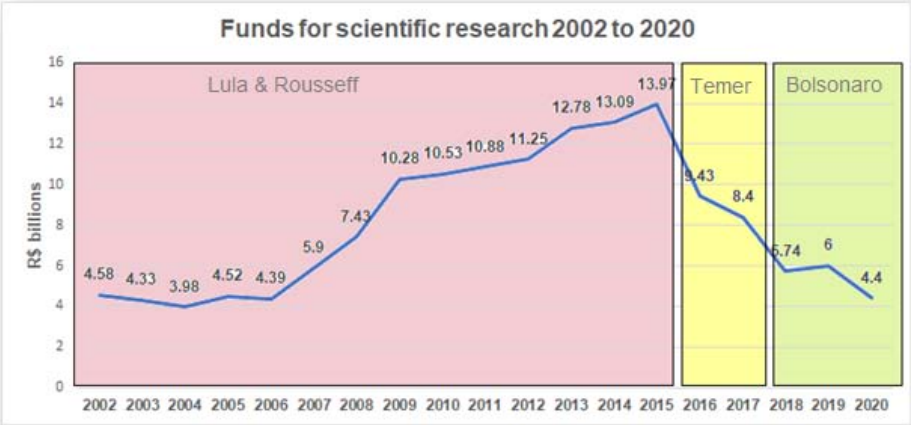
III. Discussion: Higher Education Policies from Lula to Bolsonaro

Klein and Schwartzman (1993) affirmed that the analysis of higher education policies produced in Brazil in the period of 1970-1990 showed "*patterns of policy-making that are closely related to the nature of the political regimes under which they occurred*". After Rousseff's deposition, although Brazil is still a formal democracy, a radical transformation from the PT's governments to Temer and Bolsonaro also resulted in a dramatic change in policymaking. In comparative Table 1.0 below, we outline the main differences among the past four governments in their educational policies.

Table 1.0: Comparative table detailing policy in every studied period.

	Lula da Silva (2003-2011)	Dilma Rousseff (2011-2016)	Michel Temer (2016-2018)	Jair M. Bolsonaro (2019-)
Political view	Central-left - Welfare state	Central left	Central-right - Liberal	Extreme-right - Liberal
Foreign Policy initiatives in Education	UNILA/UNILAB	Science without Borders BRICS	None	None
Educational programs	REUNI Reformed FIES ProUni SISU PNAES	Science without Borders "Law of Quotas"	No new programs. Science without Borders was extinguished. Reduction of higher educational investments.	Future-se (abandoned)
Number of public HEIs	224 in 2004 to 285 in 2011	296 (2016)	299 (2018)	302 (2019)[28]
Number of private HEIs	2,099 (2010)	2,111 (2016)	2,238 (2018)	2,306 (2019)
Students enrolled in HEIs	6.407.733 (2010)	8.052.254 (2016)	8.451.748 (2018)	8.604.526 (2019)
Number of new public universities	14 universities 126 campi	4 universities 57 campi	5 universities	None
Total budget spent on Educational sector	2008: R$ 66,7 billion	2016: R$ 109,90 billion	2018: R$ 114,31 billion	2020: R$ 110,65 billion

In Diagram 04 below, we demonstrate the variation of the total of funds for scientific research from 2002 to 2020. Since the deposition of Rousseff, the investments drop drastically.



Source: Elaborated by author. Sociedade Brasileira para o progresso da Ciência.

Diagram 04: Funds for scientific research from 2002 to 2020.

IV. Conclusion

The results provided in this article indicate that in the PT's governments, from Lula da Silva and Dilma Rousseff, higher education policies were a priority on the agenda and universities' internationalization was part of foreign policy strategies. Education was also a tool to promote foreign policy and a drive to develop social programs. Rousseff's impeachment ended the expansion and prioritization of higher education as public policy.

In Michel Temer's and Jair M. Bolsonaro's governments, the education sector has suffered budget cuts and a reduction in importance. Temer's administration approved unpopular bills jeopardizing social rights and budget allocation for education, health, and retirement funds. With Bolsonaro, since it is an ongoing process, we still cannot see the results clearly. However, what we have seen so far presents a denial-driven setback in many sectors, notably, in science and education policies.

Bolsonaro denied the severity of the COVID-19 pandemic, adopting an anti-lockdown and anti-vaccination discourse, as well as supporting the use of so-called "preemptive" medication with no support in the literature. His denialist discourse is in direct clash with both the international and Brazilian scientific community. As a result, Brazil is one of the worst-hit countries by the pandemic worldwide, with over 380,000 deceased at the moment that we finish this article.

It is impossible not to mention the impact of the COVID-19 pandemic on Brazil's higher education *alumni*. All public and private campuses are closed, and the classes are held online. In an unequal country such as Brazil, access to computers and the internet is highly uneven. There was no initiative from the Ministry of Education to support universities. Reports show the institutions have used their own resources to cover emergency support for students. In addition, the economic context of impoverishment, increased income inequality, and unemployment leads many quota students to search for jobs to support their families. Though there is no consolidated data on schooling evasion, there is a general perception it has increased.

Already functioning under political, economic, and sanitary constraints, public higher education universities will face new challenges in 2022. The Law no. 12.711/2012, the Law of Quotas, establishes that:

> "Art. 7th - Within a period of ten years from the date of publication of this Law, the revision of the special program for access to higher education institutions for black, brown and indigenous students and for people with disabilities, as well as those who have completed high school in public schools, will be promoted".

Following years of decline in financing, which resulted in a setback in the creation of new student places in the universities, the PT's legacy in education will be faced with a debate on whether or not the inclusion of those ethnically and economically marginalized in the Brazilian society will prevail.

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[1] The focus on the second term is justified by the fact that the majority of higher education policies implemented occurred during this period.

[2] According to Senner (2003:36), the foreign policy matrix "concerns the more general outlines of a country's foreign policy and seeks to determine the way in which it conceives the dynamics of the international system".

[3] Historically, most universities were located close to the East Coast or big cities.

[4] For a detailed presentation and discussion of REUNI, see: Silva, 2017.

[5] PNE is a document edited periodically, through the law, which includes diagnoses on the Brazilian education and strategic planning proposals for the development of the sector. The current PNE, guided by Law nº13.005/2014, was approved in 2014 with a validity of 10 years. The National Education Plan (PNE 2001-2010) was based on three pillars: education as the right

for all; education as a factor of social and economic development in the country; and education as an instrument to combat poverty and social inclusion. One of the goals was to "increase the gross enrollment rate in higher education to 50% and the net rate to 33% of the population aged 18 to 24, ensuring the quality". The REUNI one development from the PNE focusing on public higher education.

[6] http://reuni.mec.gov.br/noticias/37-noticia-destaque/684-lula-destaca-politica-de-interiorizacao-do-ensino-superior-e-profissional

[7] 1909 was the year of the creation of the first university, the Manaus Free University School.

[8] http://portal.mec.gov.br/ultimas-noticias/212-educacao-superior-1690610854/16096-presidente-Lula da Silva da Silva-entrega-campi-de-universidades-e-institutos-federais

[9] Created in 1998 during Cardoso presidency, the National High School Examination (ENEM) was a standardized Brazilian national exam that evaluated students' academic performance at the end of basic education. The exam improved its methodology and, in 2009, it started to be used as a mechanism of access to higher education through the Unified Selection System (SiSU), the University for All Program (ProUni) and agreements with Portuguese institutions. ENEM participants can also apply for student financing in government programs, such as the Student Financing Fund (FIES). The results of ENEM continue to enable the development of studies and educational indicators.

[10] The ENEM is also accepted in foreign universities. In Portugal, at least 50 institutions accepted the exam grade to select Brazilian candidates. The United Kingdom, France and the United States are also accepting, but the application involves other processes as well.

[11] https://www.gov.br/pt-br/servicos/obter-bolsa-de-estudo-do-prouni/ Accessed August 2020.

[12] See in "Brasil. Casa Civil. Lei nº 11.096, 13 de janeiro de 2005".

[13] http://portal.inep.gov.br/artigo/-/asset_publisher/B4AQV9zFY7Bv/content/dados-do-censo-da-educacao-superior-as-universidades-brasileiras-representam-8-da-rede-mas-concentram-53-das-matriculas/21206

[14] http://portal.mec.gov.br/rede-federal-inicial

[15] Ibope 2010, http://g1.globo.com/politica/noticia/2010/12/popularidade-de-Lula da Silva da Silva-bate-recorde-e-chega-87-diz-ibope.html Accessed 2020.

[16] Increase the number of American students in China. The Chinese government supports the initiative by awarding 10,000 scholarships (Bridge Scholarships) to American students.

[17] For a detailed analysis of this period, see Singer, 2018.

[18] For a detailed, see http://www.funag.gov.br/ipri/images/repertorio/diretrizes-governo-Temer-Ministro-Serra.pdf

[19] Venezuela, Cuba, Bolivia, Ecuador, Nicaragua, and El Salvador, in addition to the Bolivarian Alternative for the Americas (ALBA).

[20] Currency quote R$ to US$ of Mayo 2021.

[21] Source: Siafi (Sistema Integrado de Administração Financeira do Governo Federal)

[22] The data take into account the primary expenses of the current budget carried out by the MEC and of leftovers from the previous budgets paid in the financial year, corrected each year by the IPCA for the 12-month period ended in June of the previous year to which the budget law refers, as required by amendment no. 55/2016.

[23] https://www.gov.br/planalto/pt-br/acompanhe-o-planalto/discursos/2019/discurso-do-presidente-da-republica-jair-bolsonaro-durante-cerimonia-de-recebimento-da-faixa-presidencial. Accessed 09/27/2020.

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[25] Using Venezuela as an example of a failure "communist" country.

[26] Olavo de Carvalho is a self-taught philosopher, responsible for the ideological base of "bolsonarism". Although he did not have a government position, Olavo de Carvalho guaranteed his influence in appointing alumni, known as "disciples", for important positions in the areas of educational and foreign policy.

[27] http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2019/decreto/D9794.htm Accessed August 2020

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Influence of Leaf Area Index on the Heat Index of a Tropic Urban Park

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Abstract- In the wake of climate change, cities need to adapt to global warming. In this context, the use of afforestation to improve the microclimate may assist in raising the quality of life for population. This objective requires research that analyzes how the variations in parameters related to canopy dynamics, such as the leaf area index (LAI) and photosynthetically active radiation (PAR) can influence thermal comfort indices. To contribute to this research, this study measured the air temperature, relative air humidity, PAR, and LAI on a monthly basis from July, 2017, to June, 2018, in an urban park in a tropical region of Brazil. Kriging maps were created for the heat index (HI), and multiple polynomial regression models were adjusted to estimate the HI using PAR and LAI data. After defining the models, positive and negative variations of LAI were tested to observe if any changes in HI occurred. The simulated results showed greater sensitivity to negative variations in LAI, in which a 50% reduction in LAI decreased the HI by 28%, particularly during the dry period.

Keywords: afforestation; air temperature; mobile transect; photosynthetically active radiation; relative humidity; thermal comfort.

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Jonathan Willian Zangeski Novais [α], Danielle Da Silva Batista [σ], Renata Luisa Ferreira [ρ], Roberta Daniela de Souza [ω], Thiago Fernandes[¥] & Carlo Ralph De Musis[§]

Abstract[1] - In the wake of climate change, cities need to adapt to global warming. In this context, the use of afforestation to improve the microclimate may assist in raising the quality of life for population. This objective requires research that analyzes how the variations in parameters related to canopy dynamics, such as the leaf area index (LAI) and photosynthetically active radiation (PAR) can influence thermal comfort indices. To contribute to this research, this study measured the air temperature, relative air humidity, PAR, and LAI on a monthly basis from July, 2017, to June, 2018, in an urban park in a tropical region of Brazil. Kriging maps were created for the heat index (HI), and multiple polynomial regression models were adjusted to estimate the HI using PAR and LAI data. After defining the models, positive and negative variations of LAI were tested to observe if any changes in HI occurred. The simulated results showed greater sensitivity to negative variations in LAI, in which a 50% reduction in LAI decreased the HI by 28%, particularly during the dry period. As the area is a region that experiences considerable variability in terms of humidity and high temperatures throughout the year, conditions conducive to thermal discomfort had often occurred in the study area. This indicates that for tropical regions, even in urban parks, it is important that users pay close attention to their hydration needs and the duration and intensity of their physical activities.

Keywords: afforestation; air temperature; mobile transect; photosynthetically active radiation; relative humidity; thermal comfort.

I. Introduction

Climate change and its impacts associated with anthropogenic actions including vegetation suppression, land use, and occupation, and the dense and compact set of constructions from constant urban expansion have become the focus of widespread discussion amongst the scientific community (Grimmond et al., 2009; Middel et al., 2014; Petralli et al., 2014). This is due to the changes in the thermodynamic field caused by the decrease in shortwave reflection and increased emission of long waves; this causes an increase in air temperature even during the periods of shorter heat stroke duration, intensifying the formation of heat islands (Ayoade, 2003; Peng et al., 2012).

Artificialized areas, mainly in the central regions of cities, produce greater changes in the local climate. Consequently, vegetated urban spaces contribute to better thermal comfort and the reduction of heat islands. This is because of the interception of a part of the solar radiation incident by the tree canopy; the extent of interception varies based on the species, resulting in differing attenuation of solar radiation. (Abreu et al., 2012). Herb et al. (2008) affirmed that the canopy of trees affects the heat transfer of the surface and the temperature of the soil below it, providing better thermal conditions for pedestrian movement (Souza et al., 2020).

Thus, the variations in leaf area indices (LAI) may influence thermal comfort, especially in tropical regions with seasonal precipitation. According to Llandert (1982), thermal comfort associated with the presence of afforestation is mainly related to the canopy density of each tree. Through its leaves, trees are able to absorb 15% to 35% of the received light energy, pass between 30% and 50% of the energy, and reflects the remainder of the energy (~30% to 40%), during the daytime.

The constant concern on promoting the quality of life in cities and the health of the population has fostered the use of research and different methodologies, to demonstrate the effective action of vegetation on the urban microclimate (Bueno-Bartholomei, 2003; Abreu and Labaki, 2008; Monteiro and Alluci, 2008). Grimmond and Oke (1991) and Krayenhoff et al. (2014) have shown that soil and vegetation can moderate the local microclimate by delaying the release of water through evapotranspiration, reinforcing the importance of urban parks in cities climate. Ren et al. (2013) confirmed that the population recognizes urban parks as an oasis amid the dense urban construction model, acting to alleviate the thermal discomfort of heat islands.

One way to measure a user's comfort index is the heat index (HI) method proposed by Steadman (1979a, 1979b, 1984). This method is one of the most popular environmental health indices, providing the basis for heat warnings in many communities of the United States of America (NOAA, 2009). The heat index has also been applied in several regions and climates in

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[1] *Abbreviations*: GRG: generalized reduced gradient; HI: heat index; LAI: leaf area index; MODIS: Moderate Resolution Imaging Spectroradiometer; PAR: photosynthetically active radiation; SQDP: sum of squares of weighted deviations; SSR: sum of the squares of residues.

Brazil. For example, Nóbrega and Verçosa (2011) applied the HI in Recife, a seaside town with an Am climate according to the Koppen classification. Silva and Streck (2014) applied the HI to the Cfa climate in Santa Maria, a southern Brazilian city. Souza et al. (2020) applied the HI to an Aw climate classification to Cuiabá City, a midwest city in Brazil.

In Brazil, although urban parks are common, it is typical to find temperatures close to 40 °C, even in vegetated areas (Maciel et al. 2011; Pacheco et al. 2018; Andrade et al. 2019). This highlights the need to verify the comfort of users of urban parks in tropical regions and analyze how the LAI may influence thermal comfort. The objective of this study is to analyze the influence of the variations in LAI on the HIs of a tropical urban park.

II. Materials and Methods

a) Study area

This research was conducted at the Conservation Unit Ilto Ferreira Coutinho Park, located in the central region of the municipality of Tangará da Serra, state of Mato Grosso, Brazil (Fig. 1).

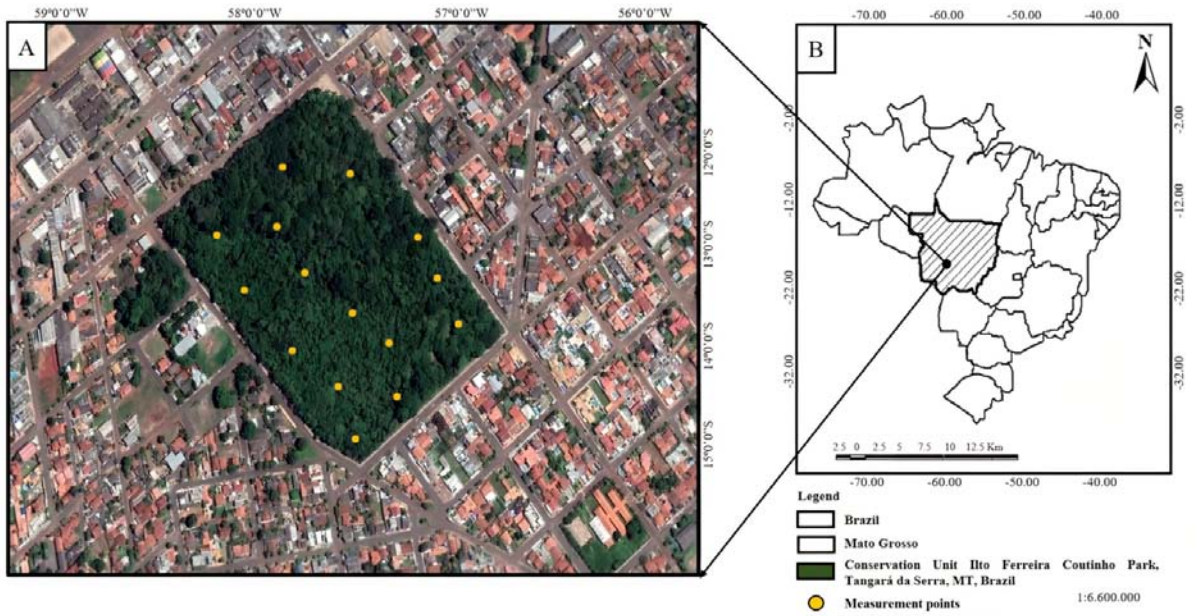

Figure 1: Map of the study area: A) Brazil and Mato Grosso State, B) Conservation Unit Ilto Ferreira Coutinho Park, Tangará da Serra, MT, Brazil.

The study area is located at 14°37'08"S and 57°29'09"W, with an altitude of 452 m and spans approximately 12 ha (Melz and Tiago, 2009). The original growth of semideciduous forest is characterized as Cerrado-Amazonian ecotone. The most abundant families are Anacardiaceae, Malvaceae, Bignoniaceae, Annonaceae, Apocynaceae, Meliaceae, Miristicaceae, and Rubiaceae, where 81% of the species are native to the region (Rodrigues, et al., 2015). There are two types of soils in the study area: red dystrophic latosol (red latosol) and hydromorphic quartzenic neosol. Based on the Köppen climate classification, the climate is Aw which is characterized as hot and humid with rain in the summer and drought in the winter with wet and dry seasons (Alvares et al., 2013). The surroundings are composed of commercial areas and single-story residences, with very little shade generated by buildings.

b) Measurement of Environmental Variables and Study Period

Air temperature and relative humidity were collected for one year, on a monthly basis, Data collection commenced in July 2017 and ceased in June 2018, from 8 am to 5 pm, with an hourly collection, at a central park point; the averages were subsequently calculated. Collection days were preferentially chosen when there was no rain or cloud, based on the method described in Oke (1982). Measurements were obtained using a portable microclimate station (Kestrel 4500 Weather Tracker, NK Company, Boothwyn, PA, USA).

The incident photosynthetically active radiation (PAR) data and LAI were collected at 12 pm at 15 points distributed throughout the park; the averages of these values were calculated following the measurement. This data was measured using a linear ceptometer (AccuPar - LP 80, Decagon Devices, Washington, USA).

The mobile transect method was used for geostatistical analysis, with air temperature and relative humidity data collected every minute during a trip that covered all regions of the park. The collections were made at 8am, 12am, and 5pm , in January and June 2018, to cover the seasonality of the region. The HI was calculated based on these results, and the semi-variograms and kriging map were obtained. Data was

collected at a height of approximately 1 m from the ground, according to the guidelines in Ferreira et al. (2015), França et al. (2016), Porangaba and Amorim (2017), França et al. (2018), and Alves et al. (2019). Because the sensor is open path, not aspirated, it was also important that measurements occurred when the air was not completely stagnant during the study to minimize lags in sensor response (Sun, 2011).

c) Heat index

The HI was calculated for thermal comfort analysis, often used for hot regions with low-intensity winds and where an individual is in the shade. This results in the body thermal sensation based on the air temperature and relative humidity (Steadman, 1979b).

The HI was proposed by Steadman (1979a), according to Equation (1):

$$HI = -42{,}379 + 2{,}049015230 * T_{air} + 10{,}14333127 * R_h - 0{,}22475541 * T_{air} * R_h - 6{,}83783 * 10^{-3} * (T_{air})^2 - 5{,}481717 * 10^{-2} * (R_h)^2 + 1{,}22874 * 10^{-3} * (T_{air})^2 * R_h + 8{,}5282 * 10^{-4} * T_{air} * (R_h)^2 - 1{,}99 * 10^{-6} * (T_{air})^2 * (R_h)^2 \quad (1)$$

where HI is the heat index (°F), T_{air} is the actual air temperature (dry bulb temperature) (°F), and R_h is relative humidity (%). The data in °F was subsequently converted to °C.

The HI results were analyzed according to alert levels detailed in Table 1.

Table 1: Alert level and description of possible physiological consequences to the human body according to the heat index (HI).

Alert level	Heat index (HI)		Symptoms
	°F	°C	
No warning	< 80	< 27	No problem.
Caution	80–90	27-32	Possible fatigue in cases of prolonged exposure and physical activity.
Extreme caution	90–105	32–41	Possible cramps, sunstroke, and exhaustion due to prolonged exposure and physical activity.
Danger	105-130	41–54	Cramps, sunstroke, and likely exhaustion. Possible brain damage due to prolonged exposure to physical activity.
Extreme danger	> 130	> 54	Stroke or action and risk of imminent cerebral vascular accident.

Source: Adapted from the National Weather Service Weather Forecast Office, NOAA.

d) Statistical Analysis

The T-test test was used to verify possible statistically significant differences to air temperature, relative humidity, and HI, at a significance level of 5%. This was carried out to verify possible differences between the periods, and the Pearson's correlation was used to identify dependencies between meteorological variables.

For spatial analysis, semi-variograms were adjusted to the results of the HI. The semi-variance measures the degree of dependence between two samples. It increases as the distance between points increases, until it stabilizes at the point known as the threshold (Co + C1), with half the hope of variance between the pairs of points separated by a distance "h" represented by the classic model, according to Equation (2) as follows:

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(x_i) - Z(x_i + h)]^2 \quad (2)$$

Where γ (h) is the estimator of semi-variance for each distance, h; N(h) is the number of pairs of points separated by the distance, h; Z(x) is the regionalized variable at point, x; and Z(x+h) is the value of point x+h (Burrough and Macdonnell, 1998). The semi-variogram is represented by the plot of h versus h. The theoretical semi-variogram generated by this function must be adjusted with a theoretical model that provides the parameters nugget effect (Co), sill (Co + C1), and range (Ao). The degree of spatial dependence of variables was classified according to Cambardella et al. (1994); there was strong spatial dependence when semi-variograms had a nugget effect that was 25% from the threshold, moderate when between 25 and 75%, and weak when greater than 75%.

The theoretical semi-variogram models consisted of spherical, exponential, and Gaussian models described by Andriotti (2003) and Yakamoto and Landim (2013). These models were used to estimate the semi-variance at any distance between samples using the developed GS + (GS +, 2000) software by Gamma Design Software and spreadsheets. The selection of most optimal semi-variogram adjustment method was important as this is the reference point from which the spatial correlation

structure to be used in the inferential kriging procedure is interpreted (Dias et al., 2015).

The evaluation and selection of most optimal adjustments of experimental semi-variograms were based on the smallest sum of the squares of weighted deviations (SQDP) and the highest coefficient of determination (R^2; Andriotti, 2003; Yakamoto and Landim, 2013). The interpolation and spatialization of the variables were then carried out using the punctual ordinary kriging; their spatial distribution was subsequently analyzed.

For models estimating the HI as a function of PAR and LAI, the multiple polynomial regression method was applied, using the Solver tool of Microsoft Excel®. This tool uses the generalized reduced gradient (GRG) as the solution method, adjusting five parameters (A, B, C, D, and E) as per Equation (3):

$$HI_{mod} = (A * LAI^B) + (C * PAR^D) + E \quad (3)$$

After determining the adjusted equation, a t-test was conducted to compare the calculated and modeled data. The LAI was varied positively and negatively by 10%, 20%, 30%, 40%, and 50%, to enable projections on how LAI variation may interfere with HI.

III. Results

a) Hourly and Seasonal Analyses

Hourly averages were determined for air temperature, relative humidity, and HI data for mobile transects conducted in dry and rainy periods, as shown in Fig. 2.

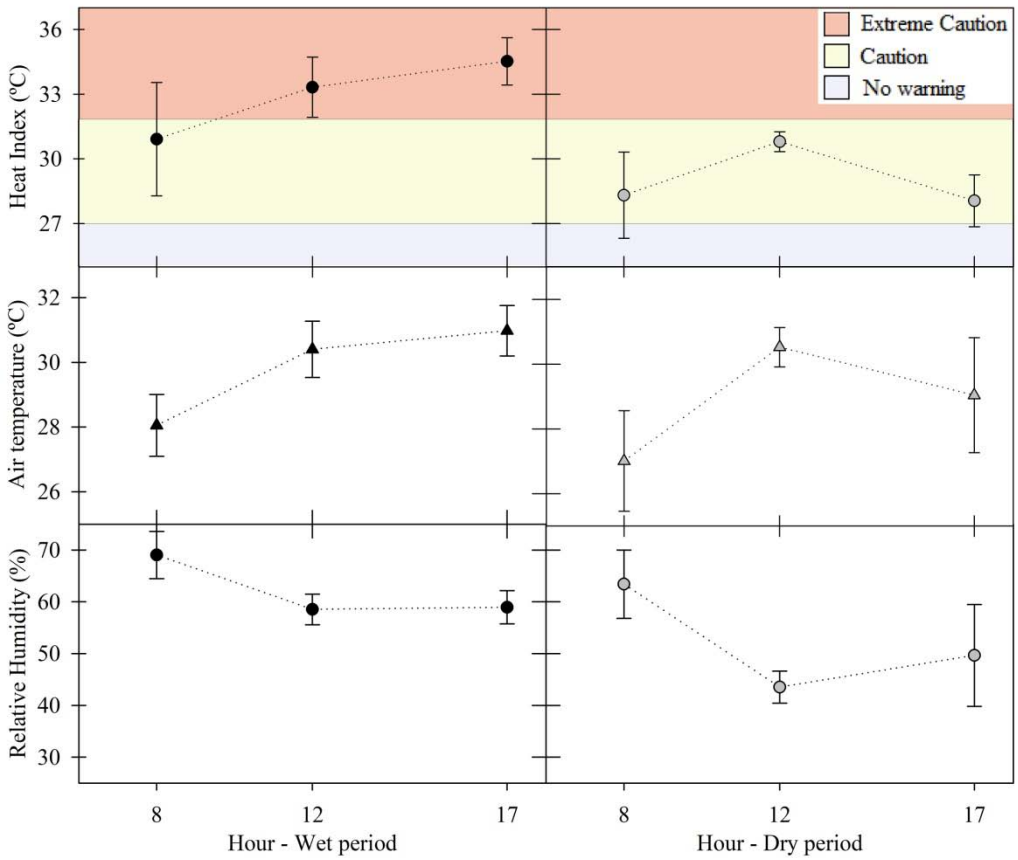

Figure 2: Hourly averages and standard variation for data on heat index, air temperature, and relative air humidity for urban park transects for wet and dry periods.

For the wet season, 12 h and 17 h were classified as "Extreme Caution", according Table 1, and 8 h as "Caution". The greatest discomfort observed occurred at sunset at 17 h, reaching 34.52 ±1.09 °C. The wet season is the period has the highest incidence of solar radiation, as it is summer in the Southern Hemisphere; this equates to higher temperatures and relative humidity. During the dry period, the average

temperatures over the three measurements throughout the day were always within the "Caution" classification.

Possible edge effects may contribute to the greatest standard deviations observed in during the mornings; this was a variation of 2.62 °C for the wet season and 1.99 °C for the dry season. The regions outside the park were observed to heat up relatively rapidly due to the specific heat of the building materials. This was an occurrence that had been attenuated during other times as the park heats up.

For seasonality analysis, the difference in median values between the two groups for air temperature, relative humidity, and HI was greater than expected, a statistically significant difference was observed ($P < 0.001$). Thus, the seasonality results follow local weather patterns.

Spatial analyses were conducted to observe the distribution of the HI in the park and possible edge effects. For this purpose, semi-variograms were calculated according to Table 2.

Table 2: Adjustment of semivariograms for heat index: model, nugget effect (Co), sill (Co + C), range (Ao), determination coefficient (R^2), and sum of squares of residuals (SSR) and spatial relationship.

	Wet			Dry		
	8am	12am	17pm	8am	12am	17pm
Model	Spherical	Exponential	Spherical	Spherical	Spherical	Spherical
C_0	0.01	0.57	0.41	0.01	0.10	0.001
$C_0 + C$	8.51	2.56	1.49	4.48	0.35	3.01
A_0	170.5	101.1	227.8	163.8	501.5	295.8
R^2	0.827	0.78	0.89	0.97	0.862	0.939
SQR	13.8	0.527	0.115	0.489	0.001	0.878
$C_0/(C_0 + C)$	0.001	0.222	0.275	0.002	0.29	0.001
	Strong	Strong	Moderate	Strong	Moderate	Strong

The largest nugget effect found (Co) was 0.57, and relatively small values of the nugget effect indicated minor errors in measurements (Dafonte et al., 2010). With the exception the 12 am measurement during the wet season in which the adjustment was exponential, all other adjustments were spherical. Of the six schedules analyzed, there was a strong spatial dependence in four; according to the classification of Cambardella et al. (1994), there is only strong spatial dependence when the nugget effect is up to 25% of the sill. Moderate dependency occurred twice, between 5 pm during the wet season and 12 am in the dry season.

The greatest range (A_0) occurred at midday in the dry period, with 501.5 m, generating the observed similarity in the special HI, as shown in Fig. 3. The lack of humidity and diminished leaf area accounted for the standardization observed in the dry season, as shown in Table 2 and Fig. 3. The range is of fundamental importance to interpret the semi-variograms, indicating the distance to where sampling points correlate with each other (Carvalho et al., 2002). This ensures that all neighboring points are so similar that they may be used to estimate values for any point between them (Machado et al., 2007).

The lowest coefficient of determination was 0.78, at 12am during the wet season, suggesting good model adjustments. Regarding the sum of the squares of residues (SSR), only the 8 am measurement during the wet season had values exceeding. As the SSR is a measure of discrepancy between the actual and modeled data, a small SSR indicates a tight fit between the model and the measured data (Draper and Smith, 1998).

The spatial patterns follow the hourly patterns shown in Fig. 2, in which in the spatial analyses of the wet season showed that thermal discomfort was greater in this season than the dry season. Dense vegetation cools the air as it prevents radiation from reaching the forest floor (Napoli et al., 2016) and provides a larger surface area for evaporative cooling. However, the incidence of radiation in the summer season was able to elevate air temperatures, resulting in higher heat levels during the wet season.

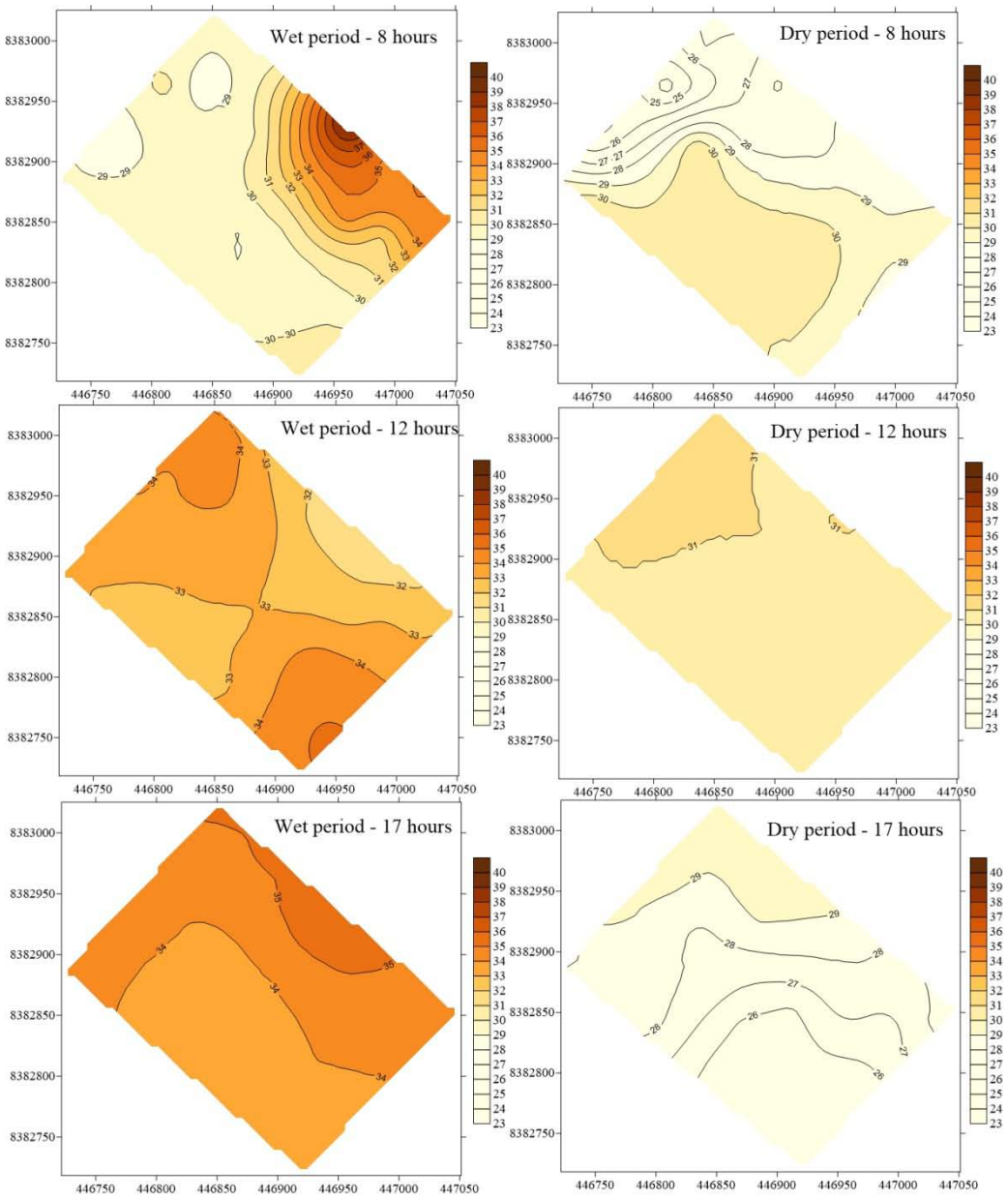

Figure 3: Kriging map for the heat index for times 8, 12, and 17 in the dry and wet periods of the year 2018 for the urban park.

b) Monthly and Model Analysis

Fig. 4 shows the monthly averages of analyzed variables.

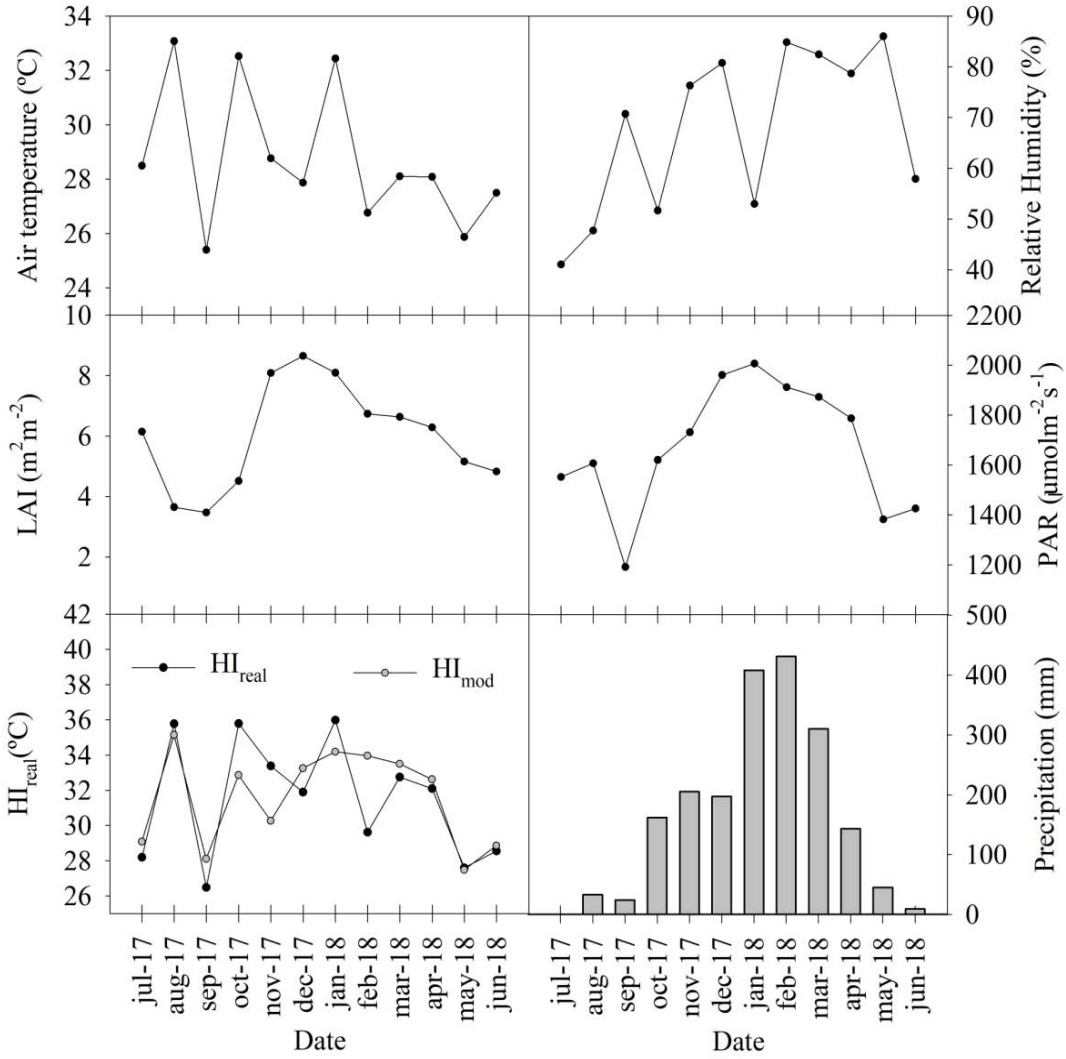

Figure 4: Monthly averages of air temperature, relative air humidity, leaf area index, photosynthetically active radiation, and real and modeled heat index.

According to the Pearson's correlation test (r), air temperature and relative humidity were negatively correlated ($r = -0.666$ and $p > 0.01$). This means that an increase or decrease in air temperature results in an increase or decrease in relative air humidity. Varejão-Silva (2006) explained that such behavior is caused by the inverse proportionality of the relative air humidity and the vapor saturation point. Therefore, the relative air humidity will also be inversely proportional to the air temperature.

The annual average LAI was approximately 6 m^2m^{-2}, demonstrating regional seasonality. These values are close to those reported by Sanches et al. (2008) who used the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite and reported values between 5.25 to 5.54 m^2m^{-2} for another area of the Cerrado-Amazonian ecotone forest. As the urban park vegetation is a seasonal semi-deciduous forest, leaf loss occurs from August onwards, decreasing the LAI. Another factor that contributes to lower LAI is the solar declination angle; during the dry season this angle is higher (Spolador et al., 2006; Novai et al., 2018). The greater the zenith angle, the greater the path traveled by radiation within the canopy, increasing the chance of absorption by leaves and branches (Senna et al., 2005), this increase is associated due to the measurement technique, which uses the linear ceptometer. PAR data followed the radiation pattern of the Southern Hemisphere, according to Novais et al. (2016), and LAI and PAR were strongly correlated ($r = 0.804$ and $p > 0.01$), to the maximum incidence of PAR in January, approximately 2006 mol m^2s^{-1}.

The accumulated rainfall throughout the analyzed period was 1968 mm; in July 2017, there was

no rain whereas February was the rainiest with 431 mm, which is approximately 22% of total annual precipitation. The seasonal pattern of precipitation in the study area is in line with the regional forecast as rainfall is concentrated between October and April in the Cerrado region (Dallacort et al., 2011).

Using PAR and LAI data, the following model was obtained for HI estimates:

$$HI_{mod} = (51.63 * LAI^{-1.19}) + (107.57 * PAR^{0.11}) \pm 216.29 \quad (4)$$

The difference between the mean values of HI_{real} and HI_{mod} was insufficient to reject the possibility that this difference was due to random sampling variability. There was no statistically significant difference between the groups (P = 0.996), justifying the use of the model to simulate LAI variations.

Table 3 presents the annual averages of the HI for each model variations and their respective differences from the original value.

Table 3: Average annual heat index values for the LAI models.

		0%	10%	20%	30%	40%	50%
HI	LAI +	31.504	30.77	30.17	29.67	29.25	28.89
	LAI -		32.42	33.58	35.11	37.21	40.25
Variation	LAI +	-	-2.34%	-4.24%	-5.83%	-7.17%	-8.32%
	LAI -		2.88%	6.58%	11.44%	18.11%	27.74%

** LAI + corresponds to positive variations in leaf area index and LAI- to negative variations.*

The addition of 50% LAI improved the annual average HI by approximately 8.32%, whereas the decrease resulted in a 27.74% decrease in the average annual HI. Fig. 5 presents the monthly HI results from the model variations according to the LAI.

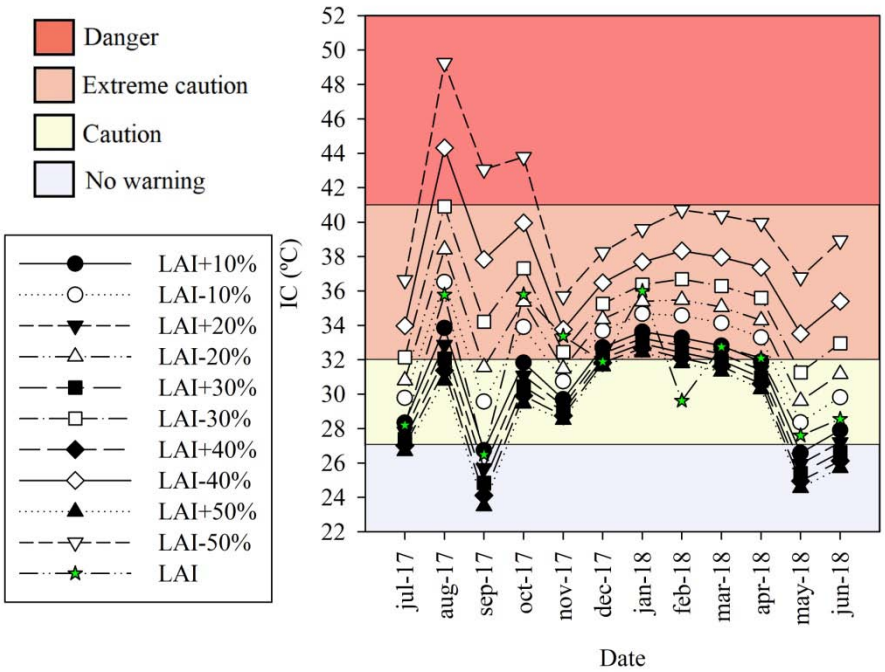

Figure 5: Influence models of leaf area index variation on heat indices.

The 50% variation of LAI showed the most concerning results, where three months were within the "Danger" classification, and the remaining months were in the "Extreme Caution" classification. The positive variations in LAI contributed to a greater number os months in the "No Warning" classification, ranging from zero months in this classification to four months for the LAI +50% model.

IV. Discussion

Based on the analysis of hourly average air temperature and relative humidity generated by the spatialized data, the wet season was more uncomfortable than the dry season. This result differs from the monthly analyses undertaken at a central point of the park. Such differences in results suggest that the spatial patterns of data collection as well as the possible influence of clearings and edges, influenced these

results. These results corroborate the scientific findings from Silva Júnior et al. (2012) for the city of Belém (Pará, Brazil), whereby for the majority of the afternoon the city is thermally uncomfortable. Neighborhoods with a higher percentage of soil sealing and lower vegetation cover exhibited greater thermal discomfort, indicating that urban elements (paved streets, houses, buildings, and vehicle routes), influence the city's climate.

In terms of the influence of the edge effect, Vasconcelos and Zamparoni (2011) and Morakinyo et al. (2017) found that the effectiveness of trees to improve daytime thermal comfort reduces with increasing urban density whereas the opposite was true for the nighttime. Therefore, as the park is not influenced by external shading due to low construction density and people do not visit the park at night, there is no problem using species that have higher LAI, as it is expected that only daytime comfort occurs. This highlights the importance of urban planning to present solutions to promote quality of life within a healthy environment.

The most uncomfortable time was at 5 pm during the wet season, suggesting that despite the high LAI of this period, which mitigates the incidence of solar radiation, air exchange is reduced, making heat dissipation difficult. The cooling effect of vegetation is likely to be lower at night when there is very little transpiration. This means less evaporative cooling (Richards et al., 2020) because of the trapped heat and humidity within the urban canopy layer, compared with the rapid nocturnal cooling of open areas (Fahmy et al. 2010). Boone (2008) explains that humidity often creates a temperature that feels hotter than reality. This is because the body cools with the evaporation of sweat due to the consumption of latent heat on the surface of the skin. However, when air humidity rises, there is a decrease in the rate of sweat evaporation, causing greater heat retention and leading to discomfort and stress (Delworth et al., 1999).

In terms of the analysis of monthly averages, the temperature decreases in September (the dry season), may be related to cold fronts, where there are sharp drops in solar incidence due to the presence of cloudiness (Biudes et al., 2015).

For model analysis, the annual average LAI was approximately 6 m^2m^{-2}; this is a relatively high value compared to cerrado forests, where Hoffman et al. (2005) found an annual average of 3.3 m^2m^{-2} for grassland and 4.2 m^2m^{-2} for riparian forest. Malhado et al. (2015) calculated an average annual LAI of 5.07 m^2m^{-2}, which was closer to Amazonian forest values.

Thus, whilst dense canopy does contribution to thermal comfort, its contribution is not as great as the decrease in LAI, which leads to greater variations in HI, making the HI reach 40.25 ^oC (extreme Caution Alert Level); this constitutes a ~28% increase in relation to measured values.

Despite the general consensus that urban parks are the places of leisure and exercise as well as oases within the urban area, in tropical areas, greater attention should be given to vulnerable users of the park, for instance, those susceptible to cramps, sunstroke and likely exhaustion, and possible brain damage due to prolonged exposure to more intense physical activities. This is because the heat indices during the dry season was largely unsatisfactory.

V. Conclusion

The LAI influences the HI, and this influence is more pronounced in models that decrease the amount of leaves. A 50% reduction in LAI caused a 28% increase in the HI, being classified as "Extreme Caution" alert level during the dry season which was found to be more susceptible to the changes in the LAI. Hourly analysis showed that the evening, especially in the wet season, was of greater concern, as there was a lack of thermal comfort even in shaded areas. The possible nighttime discomfort generated by the heat retained in the park is insufficient to cause major concern, as park visit is typically limited to the daytime. Although urban parks are recognized as a place for leisure and physical activities, greater care is suggested during the use of urban parks in tropical regions. It is recommended that park users equip themselves with light clothing, hydration, and are careful with strenuous activities, avoiding the periods of greatest thermal discomfort.

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Infrastructural Waste in Nigerian Urban Centres: Case of Pedestrian Bridges in Uyo Metropolis, Nigeria

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Abstract- Walking is the basic human instinct to move from one place to another. Even in modern cities with a well-developed traffic system, walking is still indispensable. A cross-over bridge is a facility that provides a safe and comfortable environment for all road users to move around the city without having to worry about traffic mishap. A pedestrian bridge is a type of bridge that is enclosed or covered between two sides of a road. They are constructed for the safety and convenience of pedestrians. They are aimed at decreasing traffic congestion, reducing vehicular air pollution, separating people from vehicular noise, easing traffic movement and reducing vehicular accidents in the city. They are constructed in dense traffic junctions for people in order to maintain traffic system. Unfortunately this infrastructure has become a major waste especially in terms of cost and usage; since majority of pedestrians have refused to use them but prefer to run across the high way, thereby defeating the purpose for which these bridges were constructed. Lots of accidents have thus occurred due to pedestrians crossing busy roads. About 65% of deaths have been recorded in most major cities in Nigeria and among them 35% are children.

Keywords: *infrastructure; urban waste; pedestrian bridges; uyo metropolis; akwa ibom state.*

GJHSS-B Classification: *FOR Code: 050299*

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Prof. Mbina, Anthony A [α] & Dr. Bassey, Luna E [σ]

Abstract- Walking is the basic human instinct to move from one place to another. Even in modern cities with a well-developed traffic system, walking is still indispensable. A cross-over bridge is a facility that provides a safe and comfortable environment for all road users to move around the city without having to worry about traffic mishap. A pedestrian bridge is a type of bridge that is enclosed or covered between two sides of a road. They are constructed for the safety and convenience of pedestrians. They are aimed at decreasing traffic congestion, reducing vehicular air pollution, separating people from vehicular noise, easing traffic movement and reducing vehicular accidents in the city. They are constructed in dense traffic junctions for people in order to maintain traffic system. Unfortunately this infrastructure has become a major waste especially in terms of cost and usage; since majority of pedestrians have refused to use them but prefer to run across the high way, thereby defeating the purpose for which these bridges were constructed. Lots of accidents have thus occurred due to pedestrians crossing busy roads. About 65% of deaths have been recorded in most major cities in Nigeria and among them 35% are children. Over 10 million human lives are crippled or injured each year. This article focuses on the pedestrian bridges as an infrastructural waste in urban centres in Nigeria, with Uyo in Akwa Ibom State as case study. The main thrust of the study is to find out why most pedestrians fail to use the pedestrians' bridges even at the risk to their lives.

Keywords: infrastructure; urban waste; pedestrian bridges; uyo metropolis; akwa ibom state.

I. Introduction

Lots of accidents have occurred due to pedestrians crossing busy roads. And with a very high rate of human casualties, it still baffles several observers that many city dwellers still prefer plodding dangerously when crossing busy roads in the city, than using the pedestrian bridges where available.

For a long time now, transportation has been one of the most important of man's activities in space. Man's ability to move himself and his materials from one point to another on the earth's surface significantly influences his life and his environment. Generally, resources and needs are usually spatially distributed in landscape but the areas of desires exist away from the areas of fulfillment and the spatial inequality created calls for interactions and movement within urban setting. Thus, both intra and inter city transportation system bridges this gap bringing people and resources together in both space and time. Furthermore, one of the ways by which man organizes the space around him is through the creation of settlement around him and man usually uses transportation as a tool to bring orderliness into the settlement.

However, there is the inevitability of transportation in the city and the basic necessities of life. For instance, man's basic need of food, clothing and shelter could hardly be achieved without transportation. Hence transportation could be referred to as "the life wire of our socio-economic and political life". This means that without transportation life as it is today would be inconceivable. When the relationships between transportation and city are compared, transportation is particularly carried out in the existence of a city and the existence of city is greater than demand for transport. What this means is that transportation in the city anywhere in the world denotes that transportation is a potent to influence any city growth and development. But what is being witnessed today in some emerging cities like Uyo and many others in Nigeria beset mobility problems, called "negative externality" or "maker or breaker of the cities".

Experience has shown that most urban traffic problems are further aggravated by the concentration of most of the working avenues in the same locations, such that traffic is basically in one typical direction during the morning rush hour and evening peak periods. In Uyo for example, the population of new settlers into the city from other major urban areas is hectic. Most especially new comers moving away from the northern parts of the country as a result of occasional banditry, kidnappings, religious uproar and sectorial killings. Thus the increase in the population of new arrivals is becoming more difficult to handle, especially resulting in the increasing "bumper to bumper" traffic experienced along major roads and junctions in Uyo in recent time.

This work therefore takes a critical look at what the Akwa Ibom State Government has done to be able to ease this traffic problem through provision of pedestrian bridges; and the perception of users of such infrastructure. It is to establish if the huge material and financial resources expended on such infrastructure is worth the while.

II. Methodology

At the dawn of the twenty-first century, one of the most persistent and challenging problems facing

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Nigerian cities is inadequacy and misuse of urban infrastructure and the subsequent deterioration of the available ones. The availability of less space in urban areas has increased demand for parking spaces especially in central business areas. Inadequate off-street parking in most of our urban centres has metamorphosed into the problem of on-street parking coupled with inadequate traffic management commonly experienced in most Nigerian cities.

In view of the above, this work examined the challenges posed by pedestrian bridges and traffic congestion problems in Uyo, Nigeria. The study was conducted using questionnaires, on the spot interviews and field observation. The questionnaire was designed to determine the reasons why pedestrians do not use the available pedestrian bridges in town. Four hundred and fifty one (451) questionnaires were administered to the students of University of Uyo, one hundred and seventy four (174) to shop owners and hawkers and one hundred and two (102) to commuters, making a total of seven hundred and twenty seven (727).

III. Theoretical Frame Work

The history of prefabricated steel truss bridges dates back to the 1930s when modular systems were used to meet the needs of the British military in remote locations. In the 1950s, deck girder bridges were developed as a replacement for deteriorating timber bridges. (See Fig. I below).

Figure 1: Girder Bridge

Today, truss designs are longer, wider, stronger, and more durable. These designs combined with technological improvements and manufacturing efficiencies, will continue to support the ever-growing and ever-changing needs of society as they relate to pedestrian bridges.

According to Wikipedia, a pedestrian bridge is a bridge designed for pedestrians and in some cases cyclists, animal traffic and horse riders, rather than vehicular traffic. Footbridges complement the landscape and can be used decoratively to visually link two distinct areas or to signal a transition. In many developed countries, pedestrian bridges are both functional and can be beautiful works of art and sculpture. For poor rural communities in the developing world, a pedestrian bridge may be a community's only access to medical clinics, schools and markets, which would otherwise be unreachable when rivers are too high to cross. Simple suspension bridge designs have been developed to be sustainable and easily constructible in such rural areas using only local materials and labour.

Pedestrian bridges are often situated to allow pedestrians to cross water or railways in areas where there are no nearby roads to necessitate a road bridge. They are also located across roads to let pedestrians cross safely without slowing down the traffic. Most pedestrian bridges are equipped with guard rails to reduce the risk of pedestrians falling. Where they pass over busy roads or railways, they may also include a fence or other such barrier to prevent pedestrians from jumping, or throwing projectiles onto the traffic below. In some cases, the bridges may be totally caged and air-conditioned, for comfort and safety. (See fig. 2) below.

Figure 2: Air conditioned pedestain foot bridge at Port Harcourt, used by NDDC staff.

a) Cost of a pedestrian bridge in Uyo

According to the Ministry of works, Uyo, Akwa Ibom State, an overhead or pedestrian bridge is estimated to cost between 7.5 to 10 million naira. That the state could go into such huge venture is because of the perceived advantages of pedestrian bridges which were highlighted to include:

- helps to minimize traffic congestion
- helps in reducing road accidents
- provides security to pedestrians while crossing roads
- enhancement of aesthetic value of the city

It was further learnt that the state government intends to erect more pedestrian bridges in Uyo, at strategic positions in an effort to turn the state into a modern city. That the state government would ensure that it provides pedestrian bridges on dual carriage ways to safe guard the lives of pedestrians who cross the road. And that the pedestrian bridges would enhance the aesthetic and architectural features of the state and help avoid loss of lives during the yuletide and other festive periods.

b) Study Area

Akwa Ibom State has one of the highest population densities in Nigeria. It lies between latitude 4°321 and 5°331 North and longitude 7°251 and 8°251 East. The state covers a total area of 604 km^2 (233 sq mi), elevation of 32 m (105feett) above sea level, has a population of over 5 million people and more than 10 million people in the diaspora. Akwa Ibom State was created in 1987 from the former Cross River State. Uyo, the capital city of Akwa Ibom State is located approximately between latitude 5 00' and 5 05' North of the equator and longitude 7 45' and 7 55' East of the Green Wich Meridian. There are currently four pedestrian bridges in Uyo metropolis. These include:

- pedestrian bridge at Edet Akpan Avenue.
- pedestrian bridge at Ikpa Road by University of Uyo, main gate.
- pedestrian bridge at Ikpa Road by University of Uyo, Annex campus, and
- pedestrian bridge at the Ibom plaza.

Location: Edet Akpan Avenue

Location: Edet Akpan Avenue

Location: Ikpa Road (University of Uyo Main Gate)

Location: Ikpa Road (University of Uyo Main Gate)

Location: Ikpa Road (University of Uyo Annex Campus)

Location: Ikpa Road (University of Uyo Annex Campus)

Figure 3: Pedestrian Crossings in Uyo Metropolis

IV. Discussion of Findings

a) Why Uyo Residents Neglect Pedestrian Bridges

Our investigations show that most pedestrians avoid the use of pedestrian bridges in Uyo like in other cities of Lagos, Port Harcourt and Abuja; thus raising the question if the huge amount invested in this infrastructure is not an economic waste. A handful of respondents have the following to say why they prefer running across very busy streets instead of using the pedestrian bridges:

- Uduak Ndomson says "I have used it once and it is scary! The design of most of the bridges is not friendly at all. They are too long and too high for those who have phobia for height. I will rather take a keke (tricycle) that is going to the other side of the road than climb a bridge."
- Stanley Etim, a photographer says Ikpa road is too narrow for a pedestrian bridge. He also noted that there is a speed bump close to the Annex gate so why build a bridge there when vehicles usually slow down when they approach there.
- A physically challenged person, Idongesit Okon, complained that climbing the pedestrian bridge remains a tedious task and clumsy for him and individuals like him. He also said that people like him were never taken into consideration while designing the pedestrian bridges. So if today it becomes a law in Akwa Ibom State that every pedestrian must use the bridge, what would be his faith, he asked.
- "It is faster and energy saving, to walk across the road, as the bridges are built so high, while walking when you look at cars down, you feel dizzy," so expressed Udoka Francis another resident at Annex gate.
- Mrs. Abraham Peters, a resident, who lives along Edet Akpan Avenue, said "Nigerians generally love disobeying laws; some people do not really know why they should use a pedestrian bridge when they want to cross a major road but I have never used it before.
- Dorcas Ephraim says she doesn't like using the bridge because her skirts will be open to viewers under the bridge, as the bridge is bounded by steel trusses.
- A mechanical engineering student, Adindu Okpara, said he would prefer the use of speed limiters and speed bumps than climbing the pedestrian bridge on Ikpa road.
- A resident along Edet Akpan Avenue, Mr Usungurua says "why waste such energy going up about 32 stairs, then walk across before climbing down another 32. The location is good but I would rather have the keke (tricycle) stop me at the opposite side than climb those flights of stairs.
- Ndifreke Akpaimo says "to me the pedestrian bridge at Ikpa road is not needed. The road is not an express one and I just need less than a minute to go across whereas it would take me about five minutes or more to climb the pedestrian bridge.
- Lady Glory Essien says "it is tiring, I know what it takes to climb a stair at home how much more that number in the public… besides I don't like heights.
- Catherine Okpara says "I have never climbed one before, I cannot imagine the experience".

b) Why Abuja Residents Neglect Pedestrian Bridges

There is no doubt that ensuring that Abuja residents make proper use of pedestrian crossings or overhead bridges within the Federal Capital City (FCC) has become an inexorable tough task for the FCT Administration especially its Transportation Secretariat. Ordinarily, it is safer to use a pedestrian crossing or an overhead bridge whenever one is available especially as the roads are very busy nowadays in the city, but still many residents in the nation's capital are not willing to use the bridges, when crossing major roads in the Territory. Unfortunately, for the few residents who patronize them, they are faced with inconveniences from illegal activities like roadside trading (hawking) and begging, including misdemeanour by miscreants. Consequently, there is an increasing rate of some pedestrians being killed, with many more injured or maimed for life. Surprisingly, this development had

lingered on, even with repeated assurances by the FCT administration that it has established machineries to tackle the menace head-on. According to the Administration, it has mandated the law enforcement agencies including Vehicle Inspection officers to work seriously on addressing the issue.

Figure 4: Pedestrian Bridge by Mashe Umaru Gwamna

Some said that the fact remains that part of the reasons for the total neglect or wrongful use of the pedestrian crossings, is that some residents are ignorant or refused to understand that the pedestrian bridges are meant to ensure their safety when crossing major roads and not punish them.

A cross section of residents, who shared their views on reason why people prefer crossing busy express roads, thereby neglecting a handful of pedestrian crossings and overhead bridges.

- A resident, who was seen along NICON junction, Mr. Sendi Longs, said "I don't know why we Nigerians love disobeying laws; some people do not really know why they should take a pedestrian bridge while they want to cross a major road. Vehicles have been killing people, which was why government came up with the idea of constructing pedestrian crossings. People should thus stop complaining about the location of these facilities, as they should know that trekking is part of physical exercise to help them keep fit. He said that people really needed to be educated, because a lot of people seem not to know the benefits of using those pedestrian bridges".
- "Crossing the road directly is faster for me, than using the pedestrian bridges, which comes with a lot of stress, as one gets tired easily, leaving pains in ones legs. The bridges are so high and the steps are too many, I had to count the staircase one day while climbing one of them, they were about 86 in number, that's too much for me, so it's better to run across the road to the other side. It is faster and energy saving, as the bridges are built so high ,while walking when you look at cars down ,you feel dizzy," so expressed another resident at Banex junction, Uloma Okafor. He said, in building the pedestrian crossings government did not consider physically challenged Persons. He therefore noted because of the failure factor in the interest of the disabled, traffic warders be stationed at strategic places along busy roads, to always stop vehicles for physical challenged persons to cross, while the government should religiously ensure that residents use the available pedestrian bridges when crossing the roads.
- Similarly, a physically challenged person, Nehemiah Sule, noted that climbing the pedestrian bridge remains a Herculean task and clumsy for him and individuals like him. "At times especially in the evening people are so choked, we get stressed up, so crossing the road directly is preferable, than going through the stress of climbing the bridges. "Crossing the roads directly has its own disadvantages, as when crossing you may calculate that cars coming are far way, but before you could realize they are very close. Most cars on express road come with speed and hit you. So it is risky, but for people like me, taking pedestrian bridge is not easy, it is even more dangerous to our health. "But Government should always consider us while constructing these bridges and other useful things that will help the citizens," he stressed.
- Furthermore, a civil servant, Usman Jubril, said road safety signs like the zebra crossing are not even used in the country, as most people are always in a hurry to get to their destinations. "Using the zebra crossing, most motorists are not patient to allow pedestrians crossing the road, as they drive their cars close to the safety lines. He advised individuals to be careful when relying on the Zebra crossings where there are no pedestrian bridges, as some drivers are nonchalant, so they hit some individuals because everyone wants to beat the traffic. Jibril said people in FCT need to be sensitised on various road safety measures - whether it is the use of pedestrian bridge or the zebra crossing. He however added that the government should make it mandatory for people to know that once they don't use any available overhead bridge or the zebra crossing there will be penalty or mobile court to persecute them.
- For Peter Osakwe, to tackle the issues of abuse of pedestrian crossings, the governments must enforce drastic measure by implementing rules that will go a long way to motivate residents to start using the facilities. "For me I love using those

bridges because no one should tell me that I need to protect my life. Even as stressful as the staircases are, I still prefer using them for my personal safety".

- Furthermore, one Odianosa Fregene, noted many people erroneously feel it was easier for them to cross the road rather than use the pedestrian crossings, as they look at the distance of the bridges and think it is awkward, without Knowing the damning consequences involved while doing otherwise. She reiterated that Governments should create more awareness to let residents know the benefits of not crossing the high ways directly
- Also, a builder, Miss. Helen Ibrahim, emphasized that the design and construction of the bridges is mainly for the safety of cars and the pedestrian. "We construct all bridges so that people would not be endangered while using the roads, because their safety is most important."The neglect of pedestrian crossings can be addressed only if the FCT administration collaborates with vital agencies to enlighten the public about the pedestrian crossings. "Pedestrian laws has been enforced by the Lagos state government, it can also be replicated here (Abuja) by the FCT administration, by commissioning some people that will force defaulting individuals to comply with the use of the pedestrian bridges. "Traffic warder, VIO and Road safety need to be stricter on the use of zebra crossing to also reduce increasing death rate from avoidable road mishaps," she stressed.
- Also, Head, Public Relations of FCT Transportation Secretariat, Ifeanyi Ughamadu, said there are many overhead bridges without encumbrances, "So I don't know why pedestrians, should not use the bridges where they are available. "If the bridge is not available and one decides to cross roads, it would be understandable, but where the bridges are available, you don't have reasons not to use them. "As a way out, he disclosed that the FCTA has since embarked on construction of barricades near the bridges, to force people to stop crossing the road directly without using them. "For instance, in Area 1 where we have provided a pedestrian bridge, we have gone a step further by constructing some barricade a kilo meter front and back from the bridge, to dissuade people from crossing the road wrongfully. "But, we find out that in most cases, even as we barricade the bridges people still go and open up the barricades, and create an opening where they will sneak through rather than use the bridges to cross major roads. (See Fig. 5)

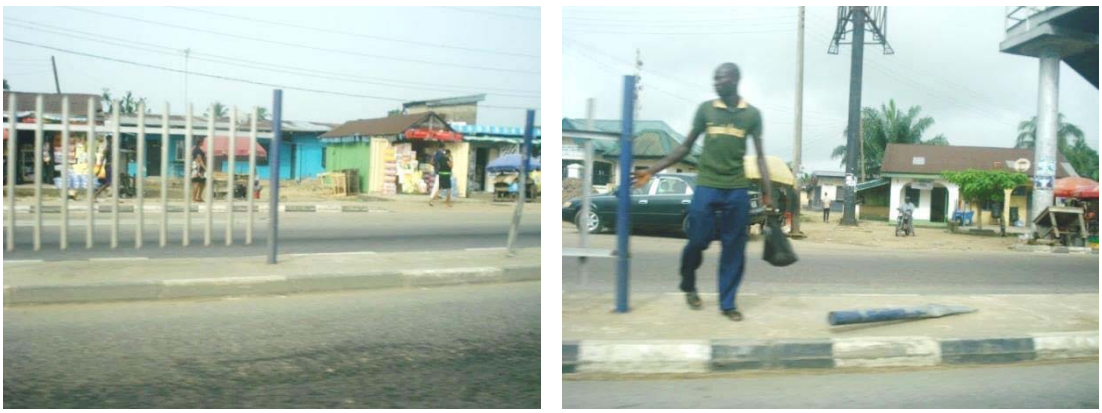

Figure 5: Damaged Barricade, to avoid using pedestrian bridge

"It is a very disturbing trend, but we are not resting on our oars to tackle the menace, because once we catch anybody doing such, of course the law is there to take care of such persons," he stressed. Continuing, he added, "We find out that most people, who are supposed to use these pedestrian bridges, are not using them because of these illegal activities on top of them. We have received reports of people being attacked on top of the bridges by all these miscreants. So we are working seriously on that. On issue of location of the bridges being far from bus stops, he said the concern is being addressed by the secretariat through synergy with transporters in the city. "We are trying force operators of high capacity vehicles to drop passengers close to where we have these pedestrian bridges. Because it would be unwise to drop passengers a kilo meter away from where the bridges are actually available. "If you notice, now most of these high capacity vehicles normally discharge passengers close to these bridges. But dismissing the allegations that the bridges are very far from junctions where the pedestrians are heading to, he said, "We don't construct over-head bridges just like that, but we take a lot of things into consideration; we look at the length of roads; various interjections etc. "We construct a bridge where there is a need for one. For instance, between National Assembly headquarters and Area 1 we have a pedestrian bridge there. So, people in the area are supposed to walk a little distance that it is just about half a kilo meter and access the bridge. "The bridge must not just be sited where you want it, if not we will have more than ten bridges within just a short distance. "The PRO therefore

pleaded with residents, not to see the pedestrian bridges as a profitable avenue for their businesses, as it is not supposed to be so, because they are forcing other people not to use the bridges. He stressed that the bridges are not meant for activities like trading, begging and misdemeanour by miscreants, but it is only meant purely for purpose of ensuring safety of people crossing major roads in the Territory. "We have gone severally to all the notorious ones, where illegal activities are taking place- to round up the miscreants doing some businesses on top of bridges, and we have taken them to our Mobile courts to be tried.

c) Why Lagos Residents Neglect Pedestrian Bridges

With pedestrians shunning the bridges on the major highways in Lagos, accidents are on the increase as the state intensifies efforts to arrest offenders, according to Motunrayo Joel.

- John Adeyemi was driving home from work on a wet Wednesday night in April when he witnessed the crushing of a young man by a lorry after he attempted to cross the expressway, shunning one of the pedestrian bridges along the Ikorodu road. Giving the gory details of the accident, Adeyemi, who works with a leading newspaper company in Nigeria, said the unpleasant experience shattered his night as the shocking incident haunted him in his sleep. He said death like this was avoidable if the need for pedestrian bridges on the expressway was appreciated. "The pedestrian bridges add aesthetic value to our society but the major reason for their construction was to avoid accidents on the roads. It is however unfortunate that people still prefer to risk their lives by crossing the road even when there are government agents put in place to arrest offenders. They prefer arguing out with the officers to using the bridges. "I would have killed the man but I applied brakes to avoid him. He was however unlucky as the lorry beside me hit him and ran over him with his body parts flying all over the road," Adeyemi said. Such deaths are becoming daily occurrences on the Lagos roads, especially on the Ikorodu Road, Lagos-Abeokuta Expressway, and areas like Ikeja and Lagos Island where the pedestrian bridges are erected. Despite warnings from the state government and its agencies, most Lagosians have chosen to turn a deaf ear to these warnings. Regardless of the risk and the fatal consequences involved in crossing the expressways, some pedestrians uphold the view that the choice to use the bridges is personal.
- Segun Olabode, said climbing the bridge was time-consuming. "I have a shop at the Computer Village in Ikeja, Lagos and every morning, I travel from Sango to Lagos. Once I get down at the foot of the Ikeja overhead bridge, I quickly cross over to the other side of the road. I don't see reasons why I should spend valuable minutes climbing the bridge. It is a waste of time. Here in Lagos, time waits for no one. Crossing the main road is much faster if I can avoid the vehicles. It's a matter of choice if I am certain that I will not be knocked down by a vehicle," said Olabode.

A trip around Lagos reveals that apart from the people who dash across the express roads at rush hour of each day, those who hawk goods on the expressways freely choose to break the traffic rule.

- Bunmi Olusola is a hawker in Ojota, who takes advantage of the gridlock on the road to sell to motorists. To her, the law banning people from crossing the highway is a way of taking away food from some peoples' tables. She said, "I can't be carrying my goods over the pedestrian bridge, it's stressful. I find it easier crossing the road. I know it's not safe, but that is what I prefer. I hawk goods here all the time so how will I make money if I have to cross the road, using the pedestrian bridges. No motorist will wait for me if I have to climb the bridge before coming to sell to them. We are used to the system."
- To some pedestrians, crossing the highway is worth the risk because of the "stress" involved in using the bridges. Mary Sidney defended those who cross the highways, blaming the act on the unfriendly design of the bridges. She said her health could not endure climbing the tall and lengthy bridges. "It is not easy climbing most of those bridges," she said. "I nearly had a heart attack the day I tried to climb one of them. The design of most of the bridges is not friendly at all. They are too long and too high for those who have phobia for height. I will rather take a bus that is going to the other side of the road than climbing a bridge."
- John Obi said the huge flow of people on the Ojota pedestrian bridge was enough to scare people from using it despite the government's effort to upgrade it to modern one. "The bridge is always filled with people climbing up and down. There is no easy movement and so I find it difficult to use. If one is not careful, you can fall on the staircase. I prefer crossing the expressway to getting stuck in human traffic," he said.
- To ensure that the people make use of the bridges, thereby stopping accidents on the roads, the Lagos State Government empowers officers of the Kick against Indiscipline to arrest anyone who crosses the road. At Ojota, many of the officers, in green uniforms, can be seen patrolling median of the dual carriageways, waiting to arrest pedestrians who break the law. The agency has an office by the foot of the bridge linking motorists with the Lagos-Ibadan Expressway. Here, offenders are tried in an emergency court and if necessary fined. One of the

officers, said his colleagues were having a difficult time persuading the people to use the bridge, adding that those arrested sometimes attempted to force their way to freedom by fighting them.

- He said, "Anyone caught crossing the expressway will be sent to our office at Alausa, Ikeja, after which the person would be taken to the Ikeja High Court. The fellow, if found guilty, would be asked to pay a fine. The guilty offender could be asked to engage in community service."
- An official of the Lagos State Traffic Management Authority said Ojota produced the highest number of traffic offenders because of the huge flow of traffic and human beings to various destinations in Lagos. He narrated the story of a man killed by a vehicle on the road.
- "Cases of people being hit by vehicles happen at least once in a week in the area (Ojota). Some of the victims thought they could move faster than the vehicles but in the twinkling of an eye, they are knocked down dead. We warn people not to cross the road but they prove to be stubborn even with the presence of agency officials," he said.
- Around the airport area in Ikeja, cases of people being knocked down as they try to cross the expressway are also on the increase. However, some pedestrians point out that the bridges are not safe sometimes. Chukwudi Ndidi said that the governments of Lagos and Ogun states had ignored the plight of the people who were left with no alternative but to cross the expressway at Berger bus stop. He said, "Everyday, hundreds of people cross the expressway. There is the need to construct a pedestrian bridge across the highway to ease the flow of people who cross the expressway. Lives have been lost there on many cases but a bridge over the road can stop this tragic occurrence."
- There are about seven pedestrian bridges between the Alaka end of the Ikorodu Road and Ketu bus stop. At night, pedestrians said it was unsafe to use any of the bridges. The same was said of other bridges in other parts of Lagos, with many of them being taken over by mad men and hooligans at night.
- "The bridge at Barracks bus stop on the Ikorodu road is a no go area at night," said Monica Johnson, who lives on Yaba road. "Thugs take over the bridge at night and we have heard cases of rape and robbery at night on the bridge, so people avoid it at night. They cross the road and it has led to the death of some people who were knocked down by vehicles," she added
- Biodun Adedeji made a case for the people living with physical diabilities in the state as the Lagos para-athlete said most of the bridges had no place for his kind. "We cannot use our wheelchairs on the bridge because they only have steps, except the new one at barracks bus stop," he said.
- Also speaking on behalf of persons with physical disabilities, the Executive Director, Centre for Citizens with Disabilities, Mr. David Anyaele, said access to pedestrian bridges in Lagos State is one of the greatest challenges for persons living with physical disabilities. He said, "In my estimation, more than 80 per cent of pedestrian bridges in the state were designed with little or no consideration for persons with mobility challenges, as such, movement for this group of people in Lagos has been restricted due to minimal or no access to pedestrian walkways. "On the Ikorodu road axis, out of the eight pedestrian bridges, only two could be described as disability-friendly. These include Obanikoro and Anthony pedestrian bridges. The situation is made worse in some areas that have no pedestrian bridges at all. Take for instance, along Lagos-Abeokuta Expressway and Lagos-Ibadan Expressway, you will hardly find a pedestrian bridge, let alone a facility to help people living with physical disabilitities to cross the roads. What this situation means is that the Federal Government of Nigeria places no human value on issues that affect persons living with disabilities in Nigeria. "Don't forget that Nigeria is signatory to the UN convention on the Rights of Persons with Disabilities. Article 9 of the convention states as follows: To enable persons with disabilities to live independently and participate fully in all aspects of life. It further states that appropriate measures be taken to ensure persons with disabilities have access, on an equal basis with others, to the physical environment, to transportation, to information and communication, including information and communication technologies and systems, and to other facilities and services open or provided to the public, both in urban and in rural areas." Anyaele stressed that the wide disparity between people living with disabilities and normal persons has made life difficult for people with physical disadvantage.
- Speaking on the issue, the Lagos Sector Commander, Federal Road Safety Commission, Nseoboong Akpabio, urged pedestrians to value their lives more. He said, "We are trying our best to raise more awareness of the dangers of not using pedestrian bridges. People should value their lives, after all these are overhead bridges built by the government with people's money. Crossing expressways is dangerous," he said, highlighting the efforts of FRSC at educating Nigerians on the use of road facilities. "Those arrested by our men are sent to the Lagos State Traffic Management Agency where they learn about road safety rules.

They also engage in community service. We also use the United Nations One-week Road safety Day to enlighten the public on the advantage of using expressway safety facilities," he said.

- Speaking on the number of pedestrians who had lost their lives between 2010 and 2013 he said, "In 2010 we lost three pedestrians, in 2011 three, in 2012 seven and in 2013 four. So, between January 2010 and May 2013 a total number of 17 pedestrians had died."
- The Lagos State Commissioner for Transportation, Kayode Opeifa, said that pedestrians' refusal to use overhead bridges was one of the reasons why there was gridlock in the state. "On the Ikorodu Road axis, pedestrians' refusal to use the bridges located at major bus stops is responsible for some of the traffic gridlock experienced in the state. Traffic builds up while motorists are trying to slow down for pedestrians who are trying to cross the highways. In my opinion and based on my assessment, the traffic build-up is not caused by commercial buses' drivers, contrary to belief of most motorists," he said.

V. Conclusion

Judging from what was found out in Lagos and Abuja, where pedestrians consistently refuse to use the pedestrian bridges, one would have thought that Akwa Ibom State government would have learnt a lesson from there and thus avoid this huge amount invested in these infrastructure in Uyo Metropolis. Furthermore, we feel the users should have been consulted as to what their traffic needs are along these roads – especially when it was mentioned, and rightly so, that Ikpa road in Uyo is just a single lane road, not prone to so much risk of pedestrian crossing, and as such will not require a pedestrian bridge. We do not belief that overhead pedestrian bridges are signs of technological advancement, especially if such bridges fail to serve their intended purpose – that of saving the lives of commuters. We therefore submit that these bridges are infrastructural waste. Alternatively, speed limiters are therefore being suggested. In addition we recommend adequate awareness where people are thought to value their lives and that of others. Furthermore, proper sensitization should be carried out on both pedestrians and motorists using major highways in the state.

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Morphometric and Morphological Analysis of Gullies in Lafia Lga, Nasarawa State, Nigeria

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Abstract- This study assessed morphometric of gullies in Nasarawa State. Soil erosion is among the most endemic environmental problems of modern times. Both primary and secondary sources of data were used for this study. As ample of 36 gully sites were carried out in three Local Government Areas representing the study area for this research work. Information on gullies morphometric, morphology, soil particles size and the coordinate of each identified gullies site were taken from the field. Instruments such as hand auger, global position system. (GPS), photograph, Abeny level, linen tape, ranging poles, pegs and measuring tape and field observation methods were also adopted. The results generated from the field were subjected to statistical and laboratory analysis. The results of the findings revealed that 44.4% of the gullies in the study area are discontinuous gullies, 55.6% were continuous gullies, while gullies in the study are at their 5% and above development. 58.3% of the sampled gullies were at a stable state of development, while 41.7% of the gullies were at an unstable state of development. It was also revealed that 38.9% of the sampled gullies in the study area were long-narrow gullies, while 22.2% were linear shaped gullies.

Keywords: morphometric, morphology, gullies, erosion, degradation.

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Keywords: morphometric, morphology, gullies, erosion, degradation.

I. Introduction

Gully erosion is the removal of soil along drainage lines by surface water run-off. According to the Department of Primary Industries and Water – Tasmania, Australia (2008), gully erosion is known to be the most destructive form of soil erosion in Nigeria, which is caused by heavy or sudden rain storms which produce concentrated run-off enlarging rills into cheap channels, the run-off cuts deep gushes or gullies of over 10 meters to 20 meters and in severe situations reaching up to or over 100 meters into the land. It occurs more generally where land slopes are steep and surface run-off is exceptionally heavy. Once started, gullies will continue to move by head ward erosion or by slumping or collapsing of the side walls changing it from V-shape to U-shape valleys (Abengude *et al.,* 1991). The United States Department of Agriculture (2006) also regards gullies as channels formed by the concentrated flow of water, removing upland soil and parent material and of size too large to be obliterated by normal tillage operations (USDA, 2006).

Rills are initial stage in channel erosion which undergoes systematic transformation into gullies. Rill erosion is defined as erosion in numerous small channels that are uniformly distributed across a slope and can be obliterated by tillage (Hutchinson & Pritchard, 2002). In these and several other areas, gully erosion is a serious threat to economic development of the localities involved. Gullies are relentless destroyers of arable land. They cut up fields, agricultural lands and sometimes-entire village into small, odd-shaped parcels and restrict the free movement of farmers and animals. They are a menace to livestock as animal frequency fall in and are unable to escape. Gullies also threaten village roads, buildings and other structures. In Akwalbom State, for instance gullies have claimed two lives and several buildings in Obotme area (Udosen, 1991), more than 20 houses and a stadium complex have been destroyed by a 1km long gully system that was initiated along Eka Street in Uyo area (Armon, 1984). Currently, gullies are eroding deeply into the major Onitsha-Owerri Road near Onitsha.

According to Fubara (1988), about 16,668km^2 or 22.8 percent of the total land surface in eastern Nigeria is affected by severe forms of gully erosion. Available records also show that in all the south eastern states except the former Rivers State, about 25,000 hectares of land are lost annually to fluvial erosion, especially by gullying. In addition, the topsoil which contains significant proportion of soil nutrient and organic matter are being washed away at alarming rates by the invidious process of sheet erosion. As the

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stabilization of gullies is the most expensive of all erosion control works as the checking and elimination of gullies often requires. Extensive earth moving and construction of dams and/or other measures, it is vital to prevent gullies from developing and this can be done through the identification of critical factors for gully initiation and sometimes general lack of information on drainage basin parameters is a failure that has contributed to the significant lack of success in solving erosion parameters in the region.

In view of the foregoing, a question which arises is what are the actual environmental factors responsible for gully initiation and sustenance in the study area? Erosional factors are simply the critical condition or a combination of factors at which soil erosion is initiated. It may be induced when an internal or an intrinsic threshold or an external or extrinsic threshold is exceeded e.g., through changes in climate or land use. It is generally known that the pattern of soil erosion changes as the vegetation cover and other factors are altered. Thus, in a given landscape whether a gully is initiated or not depends on the nature of the earth material, the extent of the vegetal cover, and the slope length and gradient all of which combine to determine, the resistance to the attractive force of fluvial processes.

During the 17th and 18th centuries, Easter Island experienced severe erosion due to deforestation and unsustainable agricultural practices. The resulting loss of topsoil ultimately led to ecological collapse, causing mass starvation and the complete disintegration of the Easter Island civilization (Rattan *et al.,* 2010). Due to the severity of its ecological effects, and the scale on which it is occurring, erosion constitutes one of the most significant global environmental problems we are facing today. Water and wind erosion are now the two primary causes of land degradation combined; they are responsible for 84% of degraded acreage. Each year, about 75 billion tons of soil is eroded from the land - a rate that is about 13 – 40 times as fast as the natural rate of erosion. Approximately 40% of the world's agricultural land is seriously degraded (Morgan, 2015). According to the United Nations (2004), an area of fertile soil the size of Ukraine is lost every year because of drought, deforestation and climate change. In Africa, if current trends of soil degradation continue the continent might be able to feed just 25% of its population by 2025, according to UNU's Ghana – based institute for Natural Resources in Africa.

The loss of soil fertility due to erosion is further problematic because the response is often to apply chemical fertilizers, which lead to further water and soil pollution, rather than to allow the land to regenerate. Soil erosion (especially from agricultural activity) is considered to be the leading global cause of diffuse water pollution due to the effects of the excess sediments flowing into the world's waterways. The sediments themselves act as pollutants, as well as being carries for pollutants, such as attached pesticide molecules or heavy metals. The effect of increased sediments load on aquatic ecosystems can be catastrophic. Silt can smother the spawning beds of fish, by filling in the space between gravel on the stream bed. It also reduces their food supply, and causes major respiratory issues for them as sediments enter their gills. The biodiversity of aquatic plant and algal life is reduced, and invertebrates are also unable to survive and reproduce. While the sedimentation event itself might be relatively short-lived, the ecological disruption caused by mass die off of aquatic plant often persists long into the future.

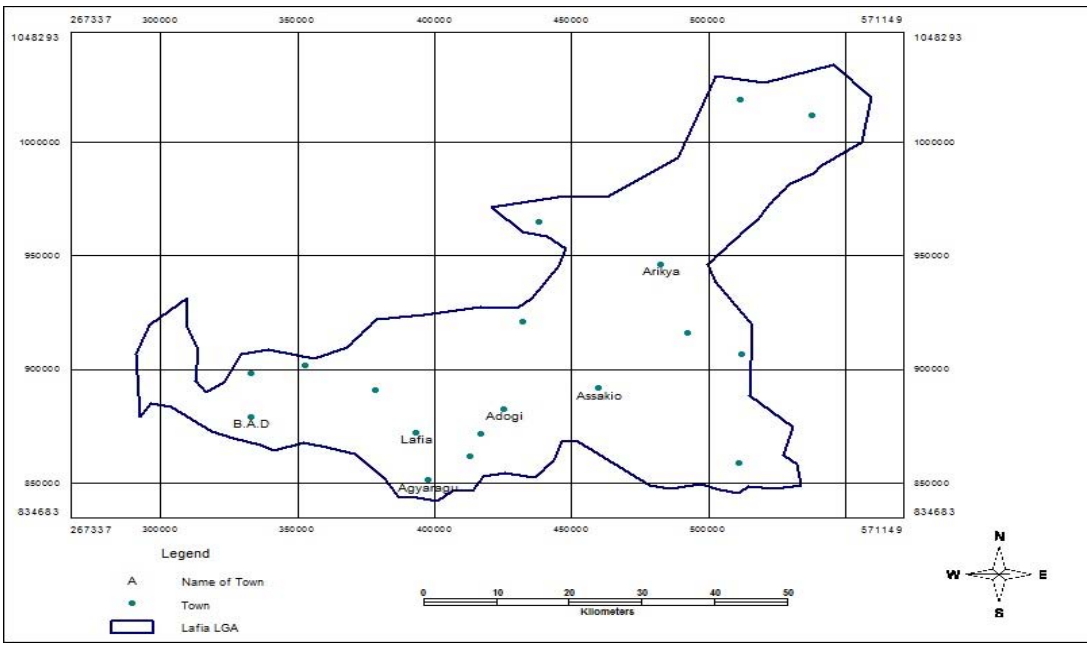
One of the most serious and long-running water erosion problems worldwide is in the People's Republic of China, on the middle reaches of the Yellow River and the upper reaches of the Yangtze River. From the Yellow River, over 1.6 billion tons of sediment flows into the ocean each year. The sediment originates primarily from water erosion in the Loess Plateau region of the northwest (Abaje, 2007). Soil particles picked up during wind erosion are a major source of air pollution, in the form of airborne particulates "dust". These airborne soil particles are often contaminated with toxic chemicals such as pesticides or petroleum fuels, posing ecological and public health hazards when they later land, or the inhaled and/or ingested (Faniran, 1978). Dust from erosion acts to suppress rainfall and changes the sky colour from blue to white which lead to an increase in red sunsets. Over 50% of the African dust that reaches the United States affects Florida. Dust events have been linked to a decline in the health of coral reefs across the Caribbean and Florida, primarily since the 1970s. Similar dust plums originate in the Gobi Desert, which combined with pollutants, spread large distances eastward, into North America (Abaje, 2007). The removal by erosion of large amount of rock from a particular region, and its deposition elsewhere, can result in a lightening of the load and mantle, causing tectonic or isotactic uplift in the region (Giles, 2011). The apparent advance of land degradation and frequent erosion occurrence in middle belt region of the country during the last 12 decades have brought about a whole series of environmental, ecological and socio-economic problems.

In Nasarawa State, a vast area of farmlands has been lost due to the menace of gully erosion while others are at their various stages of destruction leading to drastic decrease in agricultural productivity and ultimately food shortage that can lead to famine (Anzaku, 2015). The gully erosion in the state has resulted in loss of vegetation as its continuous expansion encroaches into areas that are forest leading to falling of trees and exposure of more surface area to gully activities. Several properties such as building structures whose value cannot be quantified accurately

have been destroyed. Besides, it was reported recently that several buildings were lost in Nasarawa State of Nigeria as a result of erosion (NBS News, 2014). Many lives have been lost as a result of the problem of gully erosion in the state NBS, (2012). Some either fell into these gullies or sustained various degree of injury. About 7 people have been reported in the past few years to have lost their lives as a result of flooding that drown them to gullies (NBS, 2012). Gully erosion therefore has resulted in the separation of adjacent villages and towns as it may involve collapse of bridges linking them together. This has had negative impacts on such areas since some facilities such as schools, hospitals and water supplies shared by the affected neighbouring communities may become inaccessible. Transportation of farm produce has also been affected and this also often leads to loss of agricultural products especially, the perishable ones.

II. Materials and Methods

a) The Study Area



Source: Ministry of Lands & Survey, Lafia, 2021

Fig. 1: Map of Lafia Local Government Area.

Lafia Local Government Area of Nasarawa state is located between latitudes 8° 20' and 8° 38'N and between longitudes 8°20' and 8°40'E. Lafia Local Government area has a land area of 2,797.5sq.km with a population of 330,712 (NPC, 2006). It is bordered by Nasarawa -Eggon Local Government Area and Wamba Local Government Area to the north, Doma Local Government Area to the west and south and Obi Local Government Area and Shendam Local Government Area in Plateau State to the east. Lafia's location at the junction of a regional road confers on its good linkage with Makurdi, Benue state to its south, Akwanga-Keffi and Abuja to its north-west and Jos, Plateau state its north-east.

b) Sample and Sampling Technique

Twelve (12) gully sites were purposively selected from Lafia. The sampling technique that was adopted by the researcher was the non-probability (purposive) sampling technique.

c) Types and Sources of Data

Both primary and secondary sources of data were employed in this study.

d) Identification and Characterisation of Gullies in the Study Area

Field survey, measurement, and observation was carried out. More so, soil samples of each sampled gully sites were collection and subjected to laboratory analysis, to determine the particle size of each of the sampled gully sites in the study area. GPS device was also used to get the coordinates of each identified gully in the study area. The rationale for adopting these methods was premised on the recommendations of Young (1999).

e) Determination of the Volume of Soil Loss in the Study Area

Revised University Soil Loss Equation (RUSLE) model was used for the quantification of soil loss. This

was achieved by parameterizing, combining and classifying erosion physical factors in quantifying soil loss in the general landscape (Renard, Foster, & Weesies, 1997). The erosion physical factors include: rainfall, erosivity, soil erodibility and slope length (Weesies, 1997). $A=R\times K\times LS$

While a soil erosion study that involve agricultural land use and watershed, a biophysical factor could be used. Biophysical factors include: rainfall erosivity, soil erodibility, slope length, cover and management practices, and supporting practices factors. This can be illustrated in the formulae as follows:

$$A=R\times K\times LS\times P\times C$$

Where;

A= Average annual soil loss (Ton/ha/yr),

R= Rainfall erosivity factor (mj/mm/ha/yr),

K= Soil erodibility factor (ton ha/mj/mm),

LS= slope length factor,

C= cover and management factor and

P= supporting practice factors

The procedures for estimation of these factors and soil loss can be found in many studies (Farhan, Zregat, & Farhan, 2013; Ghosh, De, Bandyopadhyay, & Saha 2013; Javed, Yasser, Shams Al-Deen, & Mohd, 2014; Kamaludin *et al.,* 2013; Khosrokhani & Pradhan, 2014, Garedew, & Yimer, 2015).

f) Determination of Gully Morphometry in the Study Area

A 30m linen tape, ranging poles, Abney level and pegs in measuring the length, width, depths and area at carefully selected points, usually at regularly space intervals of between 0.5m and 20m depending on the length of the gully in each of the sampled area of the study. A was stretched taut across it to determine the top width. Gully depth were measure from the tape of the gully bed (with another tape). The depth was measured from the gully floor to the top string using a ranging pole (graduated in meters). An Abney level was used to measure the slope angle. The length of the slope from the crest to the base from the side was measured with a 30m tape wand expressed in meters. The average value for each sampling area was also computed. This method was adopted by the researcher, in line with Mbaya, *et al.* (2012), Seutloali *et al.* (2015), and Mallam *et al*. (2016).

g) Determination of Gully Morphology in the Study Area

Field observation method was adopted in determining the gullies morphology parameters. These include the class of gullies in the study area, their shapes, and stages of development, shape factor and direction of flow, is in line with the studies of Leopol and Miller (1956), Heede (1975), Bocco (1990,1991), Ireland *et al.* (1996), and Cudoson, (2005).

h) Gullies Mapping

GPS coordinates of gullies identified during the field survey were collected and used for mapping of areas affected by gully erosion in the study area. ArcGIS and ENVIS software were used for mapping at Nasarawa Geographic Information System (NAGIS). This method was adopted in line with the works of Mbaya *et al.* (2012), Seutloali *et al.* (2015), Mallam *et al.* (2016), and Dalil *et al.* (2016).

i) Method of Data Analysis

Both qualitative and quantitative methods of data analysis were adopted. Qualitative method of data analysis was used to explained and interpret the results of the study, with respect to data extracted from field work, map analysis, and laboratory soil particle size, while the quantitative method of analysis was adopted to analysed quantitative data collected from the field. The quantitative methods of analysis adopted with both descriptive and inferential methods or statistics. Descriptive statistics such as range, mean, standard deviation, variance, simple percentages, and coefficient of variation were used to determine the variability of gullies morphometric properties and the variability of rainfall in the study area, and soil particle size, while the inferential used in the study was the correlation analysis, employed to assess the correlation between the length, depth, area and width of gullies in the study area. specifically, the Pearson Product Moment Correlation was adopted. More so, the significance of the correlation between the length, depth, area and width of gullies in the study area was tested IBM SPSS software package (version 26). These methods of data analysis were adopted by the researcher in line with the works of Mbaya *et al.* (2012), Seutloali *et al.* (2015), and Mallam *et al.* (2016).

III. Results and Discussion

a) Characterisation of Gullies in the Study Area

It is important to note that the morphological expression of gullies depends on the landscape unit, stages of development of the gullies, the characteristics of the soil profile, the slope position on which they develop and the dominant processes of the gully deepening and widening. Two criteria are generally employed in the classification of gully system; topographic location in relation to an established drainage system, and the nature of the material in which they are formed (Brice, 1966, Ebisemiju, 1979). Brice (1966) argued that the depth of a gully, its real pattern and its growth are more closely related to the topographic position of the gully head than any other single factor. Generally, incipient gullies in the study area have deep and narrow channels with sharp pointed

head scarp, while mature gullies are deep, wide and are characterised by broadly-lobed heads.

The data presented in Table 1, and 2, were obtained from Lafia Local Government Area of Nasarawa State. Table 1 depicts the general characteristics of gullies in the study area, such as the length of gullies, the area of gullies, the width of gullies, and the depth of gullies. The table also show the various cross sections of gullies in the study area, as well as particle sizes such as sand, silt, and clay. Table 2 on the other hand depicts the geographical coordinates of gully sites, as well as the magnitudes of gullies in the study area. From the results presented in these tables as well as photographs taken from the various gully sites visited, it is important to point out that gullies in the study areas are characterised by streams, dense vegetation, and terrain-steep slopes.

Table 1: General Characteristics of Gully System in the Study Area

S/N	Gully Site	Length (m)	Area (m^2)	Width (m)	Depth (m)	Cross Section	Particle Size (%)			Textural class
							Sand	Silt	Clay	
Lafia LGA										
1	Adogi	256	1536	6	5.3	V and U Shape	90.2	3.4	6.4	Sandy- Loam
2	Akunza	88	440	5	6	U-Shape	84.2	5.4	10.4	Sandy- Loam
3	Akurba	285	4930.5	17.3	12	U-Shape	86.2	5.4	8.4	Sandy- Loam
4	Bukan-kwato	111	666	6	5	U and V Shape	86.2	4.4	9.4	Sandy- Loam
5	Danka	78	390	5	5.7	U-Shape	92.2	2.4	5.4	Sandy- Loam
6	Gandu	123	676.5	5.5	7	U-Shape	87.2	3.4	9.4	Sandy- Loam
7	Gimare	127	1016	8	6	U-Shape	88.2	5.4	8.4	Sandy- Loam
8	Kilema	315	6678	21.2	8.2	U-Shape	91.2	3.4	5.4	Sandy- Loam
9	Kwandere	112	784	7	6.5	U-Shape	91.2	3.4	5.4	Sandy- Loam
10	Tudun-Allu	252	2772	11	7	V-Shape	90.2	3.4	6.4	Sandy- Loam
11	Ungwa Shawu	298	5542.8	18.6	14	U-Shape	88.2	4.4	9.4	Sandy- Loam
12	Ungwa Tiv	154	2541	16.5	10	V-Shape	91.2	3.4	5.4	Sandy- Loam

Source: Field and laboratory analysis, 2021.

Table 2: Coordinate Position of Gullies covered by this Study

S/N	Gully Site	Latitude (N)	Longitude (E)	Magnitude
Sites in Lafia LGA				
1	Adogi	8° 29' 46"N	8° 30' 2"E	Large gully
2	Akunza	8° 28' 6"N	8° 36' 14"E	Small gully
3	Akurba	8° 29' 29"N	8° 30' 25"E	Large gully
4	Bukan-kwato	8° 28' 16"N	8° 35' 14"E	Medium gully
5	Danka	8° 29' 16"N	8° 30' 56"E	Small gully
6	Gandu	8° 29' 19"N	8° 30' 42"E	Medium gully
7	Gimare	8° 29' 45"N	8° 30' 7"E	Medium gully
8	Kilema	8° 29' 34"N	8° 30' 19"E	Large gully
9	Kwandere	8° 29' 23"N	8° 31' 16"E	Medium gully
10	Tudun-Allu	8° 29' 44"N	8° 32' 9"E	Large gully
11	Ungwa Shawu	8° 29' 43"N	8° 32' 5"E	Large gully
12	Ungwa Tiv	8° 29'31"N	8° 31' 31"E	Large gully

Source: Field work, 2021.

From the data presented in the Table 1 and Table 2, it was observed that gullies in the study area are characterised with either U-shape, V-shape or V and U-shape cross sections. Similarly, the data present in both tables shows that the magnitude of gullies found in the study area are either small, very small, medium or

large gullies. Hence, the peculiar characteristics of the sampled twelve gully sites in the study area gives a true picture of the general characteristics of gully system in the study area. More so, the mean length of gullies in the study area was 183.25m (meters), with a coefficient of variation of 0.01m, while the average area covered by gully erosion was 2331.07m^2 (meters square), with a relative variability of 0.04m^2. Similarly, the mean width of gullies in the study area was 10.59m, with a relative variability of 208.86m, while the mean depth of gullies in the study area was 6.08m, with a relative variability of 0.79m. With respect the soil particles sizes in the study area, the results depicted in Table 1, shows that the mean size of sand in the study area was 88.9%, with a relative variability of 0.03%, while the mean size of silt was 3.98%, with a relative variability of 0.25%. Similarly, the mean size of clay in gully sites in the study area was 7.48% with a relative variability of 0.37%. In terms of the cross-section of gullies, majority of gullies in the study area were U-shaped gullies. Explicitly, a total of 8 gullies in the study area were U-shaped gullies. The results (Table 2) also revealed the presence of V-shaped gullies, as well as U-V-shaped gullies in the study area. This discovery is in line with the work of Udosen (1999).

The results presented in Table 2 revealed the magnitudes of gullies in the study area. From the results, it can be observed that from the entire gully sites covered in the study area, a total of 6 large gullies were recorded in Lafia Local Government. These gullies were found in Adogi, Akurba, Kilema, Tudun-Allu, Ungwa Shawu, and Ungwa Tiv respectively. The large gully found in Akurba recorded a gully length of 285m, width of 17.3m, gully depth of 12m, and covering an area of 4930.5m^2. The particle size of sand found at this gully site was 90.2%, silt 5.4%, sand 86.2%, and clay 6.4%.

Source: Field work, 2021.

Plate 3: A typical gully site in Akurba, Lafia LGA

Gully found in Adogi recorded in a gully length of 256m, with a gully width of 6m, gully depth of 5.3m, and covering an area of 1536m^2. In terms of particle sizes recorded at Adogi site, sand had 90.2%, silt 3.4% and clay 6.4%. In Kilema, the gully found recorded a length of 315m, width of 21.2m, and depth of 8.2m. In the same vein, this gully covered an area of 6678m^2, with particle sizes of; sand 91.2%, silt 3.4 and clay 5.4%. It is important to point out here that Kilema had the largest gully recorded in Lafia Local Government Area, during the course of this study.

Source: Field work, 2021.

Plate 1: A typical gully site in Adogi, Lafia LGA

Source: Field work, 2021.

Plate 2: A typical gully site in Kilema, Lafia LGA

At Tudun-Allu site of the study area, the gully found covered an area of 2772m^2, with a depth of 7m, width of 11m and a length of 252m. In terms of particle size, Tudun-Allu site has the following underlying material; sand 90.2%, silt 3.4% and clay 6.4%. The second largest gully recorded in Lafia Local government Area in the course of the study, was at Ungwa Shawu. The gully found in this site covered an area of 5542.8m^2, with a depth of 14m, a width of 18.6m and a length of 298m. The particle size found at this site has the following; sand 88.2%, silt 4.4% and clay 9.4%.

Source: Field work, 2021.

Plate 4: A typical gully site in Ungwa Shawu, Lafia LGA

Another large gully recorded in Lafia Local Government Area was found in Ungwa Tiv. The gully found at this site covered an area of 2541m^2, with a gully length of 154m, gully depth of 10m and a gully width of 16.5m. more so, the particle size distribution recorded at this site had the following; sand 91.2%, silt 3.4% and clay 5.4%.

The results also revealed the presence of medium size gullies in the study area, as well as small size gullies. The medium size gullies recorded in the study area were found in Bukan-kwato, Gandu, Gimare, and Kwandere respectively, while the recorded small size gullies recorded were found in Akunza and Danka. At Bukan-Kwato site, the medium size gully recorded covered an area of 666m^2, with a gully depth of 5m, length of 111m and a gully width of 6m. The particle size at this gully site were; sand 86.2%, silt 4.4% and clay 9.4%. In Gundu site, the medium gully recorded had particle size distribution of clay 9.4%, silt 3.4% and sand 87.2%, covering an area of 676.5m^2, with a depth of 7m and a width of 5.5m, while the length of the gully was 123m. This site recorded particle size distribution of; clay 9.4%, silt 3.4% and sand 87.2%. Similarly, the medium gully in Gimare site covered an area of 1016m^2. In terms of length, width and depth, gullies recorded at this site had a length of 127m, width of 8m are were 6m deep. The particle size recorded at this site were sand; sand 88.2%, silt 5.4% and clay 8.4%. In Kwandere site, the medium size gully recorded had a length of 112m, covering an area of 784m^2, with a width of 7m and depth of 6.5m. The particle size distribution included; sand 91.2%, silt 3.4%, and clay 5.4%.

Source: Field work, 2021.

Plate 5: A typical gully site in Danka, Lafia LGA

The small size gully recorded in Danka site had a particle size distribution of; sand 92.2%, silt 2.4% and clay 5.4%. This gully covered and area of 390m^2, and recorded a gully length of 78m, gully width of 5m, and a gully depth of 5.7m. Similarly, Akunza site has a particle size distribution of sand 84.2%, silt 5.4% and clay 10.4%. In the same vein, the geometric characteristic, Akunza site recorded a depth of 6m, width of 5m, covering an area of 440m^2 with a length of 88m.

These findings are in agreement with Patrick (1999), Kurar and Jung (2005), Booldel*et al.* (2010), Kappel (1996) and Horton *et al.* (1996) who developed a scheme to classify water erosion hazard severity from vision erosion feature base on the destruction and intensity of erosion damage. Equally, Kappel and Horton *et al.* (1996) use the procedures of measurement of gullies in assessing erosion hazard classification. Plamental (2005) stated that, mean erosion rate in India was 25-30 tones/ha per year and about 40-1000 tones descend. Evans and Cooke (1986) stated that, in the late 1970's and early 1980's there was a sharp rise in the number of recorded cases of erosion in Britain. Soil having greater sand particles are prone to erosion compare to soil having greater clay contents (Mala, 2019). Texture of soil certainly affect soil erosion. Soil texture has its influence on infiltration or entry of water into the soil. When rainfall infiltrates rapidly, runoff is minimal thus erosion is less but when otherwise then erosion is much Mala. (2019). Clay is more resistant to erosion than sand. From the results in Table 1, it revealed that soil texture in the study area is more of Sandy-Loam. The implication was that it promotes erosion because Sand-Loam texture are not resistant to erosion (Mala, 2019).

b) Volume of Soil Loss in the Study Area

From the data presented in Table 3, it can be observed that in Adogi the volume of soil loss due to gully erosion in the area was 13037.8tons, while 11643.2tons of soil loss was recorded in Akunza site. In the same vein, 7483.2tons of soil loss was recorded in Akurba site, while Bukan-kwato had a soil loss of 12574.9tons. The data presented further indicates soil loss of 14361.2tons in Danka site, while 10005.4tons of soil loss was recorded at Gandu site.

Table 3: Volume of Soil Loss at Gully Sites Located in Lafia LGA

S/N	Gully Site	R	K	LS	Volume of Soil Loss (tons)
1	Adogi	265.86	219.7	20	13037.8
2	Akunza	265.86	196.2	20	11643.2
3	Akurba	265.86	126.1	20	7483.2
4	Bukan-kwato	265.86	211.9	20	12574.9
5	Danka	265.86	242.0	20	14361.2
6	Gandu	265.86	168.6	20	10005.4
7	Gimare	265.86	90.3	20	5358.7
8	Kilema	265.86	170.5	20	10118.1
9	Kwandere	265.86	171.8	20	10195.3
10	Tudun-Allu	265.86	118.2	20	35195.6
11	Ungwa Shawu	265.86	424.2	20	25173.6
12	Ungwa Tiv	265.86	120.6	20	2156.9
Mean Value of Soil Loss		13108.7			
Std. Deviation		8924.5			
CV of soil loss in Lafia LGA		68.1			

Source: Field and Laboratory work, 2021.

Kilema, Kwandere, and Tudun-Allu sites recorded soil losses of 10118.1ton, 10195.3ton, and 35195.6tons respectively, while Ungwa Shawu and UngwaT iv sites recorded soil losses of 25173.6tons and 2156.9tons respectively.

The mean volume of soil loss in the study area as result of gully erosion was 13108.7tons with a standard deviation of 8924.5. The coefficient of variation of soil loss in the various gully sites in the study area was 68.1tons. From the results presented in the table (Table 3), Tudun-Allu and Ungwan Shawu suffers more soil loss as a result of gully erosion in Lafia Local Government Area of Nasarawa State. The implication here is that urban settlements and building structures in this area are at a high risk of collapse, and in the occurrence of such scenario lives and properties will be lost (Dalil, *et al.,* 2016; Ibrahim, *et al.,* 2017).

The above findings in respect to the volume of soil loss in the study area coincides with Baver *et al.* (2002), who were of the position that the effect of soil properties on water erosion can be in two ways: Firstly, certain properties determine the rate at which rainfall enters the soil. Secondly, some properties affect the resistance of the soil against dispersion and erosion during rainfall and runoff. The particle size distribution is an important soil property with regards to erodibility. Generally, it is found that 35% clay are often regarded as being cohesive and having stable aggregates which are resistant to dispersion by raindrops (Evans, 2015). Evans also stated that sands are not easily eroded by water due to its high infiltration rate. In contrast soils with a light silt or fine sand fraction are very erodible. The depth of erosion is determined by the soil profile (Evans, 2015). According to Evans soil horizons below the A horizon or plough and chemical composition of the sub surface horizon can also have an adverse affected. Normally deep gullies can be cut if the parent material is unconsolidated.

c) Morphometry of Gullies in the Study Area

The results presented in Table 4 establishes the morphometry of gullies in the study area.

Table 4: Gully Morphometry in the Study Area

Gully Size	Mean values of gully length (m)	Mean values of gully depth (m)	Slope angle surface on which gullies develop
Small gullies	83.0	5.9	7.6°
Medium gullies	118.3	6.1	8.8°
Large gullies	260.0	9.4	5.5°

Source: Field work, 2021.

From the results, gully Morphometry are presented in respect to the gully size. Small gullies in the study area recorded a mean length of 83.0m. In the same vein, the mean depth of small gullies in the study area was recorded at 5.9m, with a slope angle surface of 7.6° on which gullies develop. Medium gullies in the study area recorded a mean length of 118.3m. The mean value of the depth of this size of gully was estimated 6.1 with a slope angle of 8.8° on which gullies develop. For large gullies in the study area, mean gully length was estimated at 260.0m. Furthermore, the mean value of gully depth for this size of gully was estimated at 9.4m, with a 5.5° slope surface angle on which gullies develop. The results in Table 5 further reveals the morphometry of gullies in the study area in terms of their slope profile. From the results, it can be observed that the mean length of slope of gullies in the study area was 17.2m, with a coefficient of variation of 31.4m. Furthermore, the mean slop angle on which gullies develop in the study area was 5°, with a coefficient of variation of 52. These findings are in line with the work of Udosen (1999) on morphometry of gullies in Abutme area of Akwa-Ibom State, Nigeria.

Table 5: Slope Profile Measurement in the Study Area

S/N	Gully Site	Length (m)	Slope angle (in degrees)
1	Adogi	20	8°
2	Akunza	20	7°
3	Akurba	20	6°
4	Bukan-kwato	20	6°
5	Danka	20	2°
6	Gandu	20	3°
7	Gimare	10	9.5°
8	Kilema	10	3°
9	Kwandere	20	5°
10	Tudun-Allu	20	2°
11	Ungwa Shawu	6	2°
12	Ungwa Tiv	20	7°
	Mean	17.2	5°
	SD	5.4	2.6
	CV	31.4	52

Source: Field work, 2021

d) Correlation Matrix between Gully Morphometric Properties in the Study Area

The correlation matrix presented in Table 6 reveals the test statistics that measures the statistical relationship, or association between gully morphometric properties in the study area. The results as depicted in Table 6 reveals the Pearson correlation coefficient between the length and the depth of gullies in the study area at 0.614. This coefficient thus implies a strong positive linear relationship/association between the length and depth of gullies in the study area. More so, the 1-tailed test revealed a statistically significant relationship, with a significant value (*p*-value) of 0.017.

Similarly, the results also revealed a strong positive leaner relationship/association between the area of gullies and width of gullies in the study area. This strong positive leaner relationship was found to be statistically significant with a 1-tailed test at 0.01 level, with a significant value (*p*-value) of 0.000. These results by implication, implies that there is a strong positive relationship between the length and depth of gullies, as well as the area and depth of gullies in the study area. The findings of these correlation results are in line with the work of Udosen (1999)

Table 6: Correlation Matrix between Gully Morphometric Properties in the Study Area

Correlations			
		Length of gullies (m)	Dept of gullies (m)
Length of gullies (m)	Pearson Correlation	1	0.614*
	Sig. (1-tailed)		0.017
	N	12	12
Dept of gullies (m)	Pearson Correlation	0.614*	1
	Sig. (1-tailed)	0.017	
	N	12	12
*. Correlation is significant at the 0.01 level (1-tailed).			
		Area of gullies (m^2)	Width of gullies (m)
Area of gullies (m^2)	Pearson Correlation	1	0.951**
	Sig. (1-tailed)		0.000
	N	12	12
Width of gullies (m)	Pearson Correlation	0.951**	1
	Sig. (1-tailed)	0.000	
	N	12	12
**. Correlation is significant at the 0.01 level (1-tailed).			

Source: Author's computation, 2021.

e) Gullies Morphology in the Study Areas

Table 7: Gullies Morphology in the Study Area

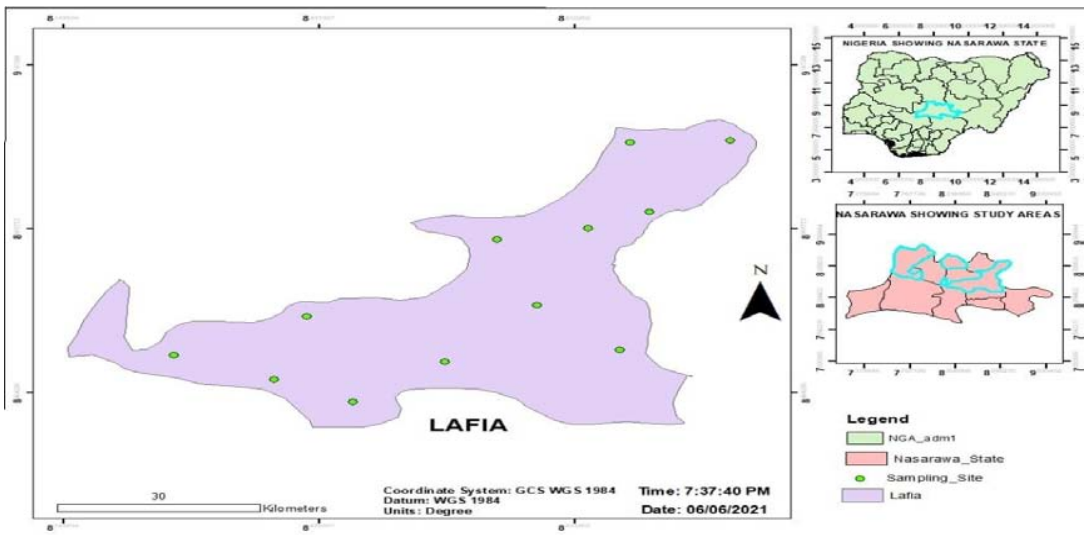
S/N	Gully Site	Gully Shape	Gully Class	Stage of Gully Development
Sites in Lafia LGA				
1	Adogi	Long-narrow	Discontinuous gullies	Unstable
2	Akunza	Trapezoidal	Discontinuous gullies	Unstable
3	Akurba	Rectangular	Discontinuous gullies	Stable
4	Bukan-kwato	Long-narrow	Continuous gullies	Stable
5	Danka	Long-narrow	Discontinuous gullies	Stable
6	Gandu	Linear	Discontinuous gullies	stable
7	Gimare	Rectangular	Discontinuous gullies	Unstable
8	Kilema	Trapezoidal	Discontinuous gullies	Unstable
9	Kwandere	Linear	Continuous gullies	Stable
10	Tudun-Allu	Long-narrow	Discontinuous gullies	Stable
11	Ungwa Shawu	Trapezoidal	Discontinuous gullies	Unstable
12	Ungwa Tiv	Long-narrow	Discontinuous gullies	Stable

In assessing the morphology of gullies in the study area, the study took into consideration the shapes of gullies in the study area, the various classes of gullies in the study area, as well as the stages of gullies development in the study area. The results presented in Table 7 shows the morphology of gullies in the study area. In determining the various classes of gullies in the study area, the methods of Ireland, *et al.* (1996) and Leopol and Miller (1956) were employed. From the results presented in the Table 4.5, it can be observed that 44.4% of the gullies in the study area are discontinuous gullies, while 55.6% were continuous gullies. Discontinuous gullies are characterized by respectively low or gentler gradients and they are caused by local over-steeping of slopes due to aggravation. This method was applied by Heede (1974, 1970, and 1976), Cudoson, (2005), and Blon (1966, 1970) in the north island of New Zealand. Mosley (1972), recorded in Bocco (1990) studied a discontinuous gully system in alluvial fills in the Colorado piedmont (USA). In this study, the characteristics of gully morphology were agent which operates frequently during heavy rain or strong winds. Gully system is said to be discontinuous when it reached it shape of maturity. Heede (1975) in an attempt to predict gully growth and guide consideration works combine the concept of discontinuity with that of stages of cyclic gully development. Based on field observation on the flanks of the Rocky Mountains (USA), he noted that discontinuous gullies represent youthful stages in gully development. Continuous gullies. These gullies in the study are at their 5% and above development. The stage of gully development consists of the development of the channel cut through the top soil and upper 'B' horizon. The early stage of a continuous gully, characterized by several knick points on the channel both on, can be termed the 'early mature' of development (Bocco, 1991).

The morphology of gullies in the study area in terms of the stages of gullies development was also analysed in line with the study of Heede (1975). From the results presented in the Table 7, 58.3% of the sampled gullies were at a stable state of development, while 41.7% of the gullies were at an unstable state of development. In respect to the shapes of gullies in the study area, in line with the study of Heede (1975), 38.9% of the sampled gullies were long-narrow gullies, while 22.2% were linear shaped gullies. In the same vein, rectangular shaped gullies found in the study area consisted of 22.2% of the sampled gullies in the study area, while 13.9% of the sampled gullies in the study area were trapezoidal shaped gullies. Long-narrow and rectangular shaped gullies consisted of 2.8% of the sampled gullies in the study area.

f) Mapping of Areas Affected by Gully Erosion in the Study Area

The effects of gully erosion in an environment can be control if only the most prone areas are properly mapped out, and precautionary measure are taken (Leopold *et al.,* 1964, and Mackin, 1948). Thus, the various areas affected by gully erosion in the study area were mapped using the coordinates collected from the identified site and depicted in Figure 3,4,5& 6. The dots in the map represents the identified gully sites in the study area (see the Map Legend). From the map, it can be observed that the various gully sites from Wamba Local Government Area were not too far from one another. This was because of the nature of the terrain of the sampled point. Similarly, Gully sites in Lafia Local government as indicated by the dots on the map are also close to each other. This finding is in line with the work of Kertész, and Gergely (2011)



Source; NAGIS, (2021)

Fig. 4: Mapping of sampling site in Lafia LGA (Results from table 4.2)

IV. Conclusion

This study assessed the Morphometry of gullies in Nasarawa State. Nasarawa State is facing severe problem of gully erosion, causing untold hardship and depression on the lives of the people of the State. Complex interdependent mechanism between rainfall characteristics, soil erodibility, land use, and topography has reduced infiltration, which caused a higher surface runoff. This has increased deep cutting, take up valuable land, raised the cost of living, and raised the cost of building and sinking of well water. The chain of the cause and effects hints most of the low-income groups of the communities where the population density is highest and where the worst damages of gully erosion are found. The paradigm of sustainable development requires equality and harmony of environment, economy, and society. And sustainable development is not possible unless this equality is felt by the masses.

Environmental degradation leads to resource degradation, declining standards of living, the extinctions of large numbers of species, health problems in the human population, conflicts between groups fighting for dwindling resources, water scarcity and many other major problems (UNESA, 2002). If this trend is allowed to continue, the long run impact of environmental degradation would result in local environments that are no longer able to sustain human populations. Such degradation on a global scale would, if not addressed, can lead to the extinction of human life on earth. In order to achieve sustainable development, a conscious effort needs to be made today to sustain the environment and prevent further degradation; various local, regional and national governments and local, regional, national and international agencies needs to work together towards promoting environment friendly lifestyle and protecting the fragile ecosystems of the planet.

V. Recommendations

On the basis of the findings of the study, the following recommendations were made;

1. Gully extent magnitude can have controlled grazing, conservation farming of vegetation barriers against run-off, especially around fresh gully leach-cats as measure of combating gully erosion in the affected areas.
2. The soil of Nasarawa State can be conserved from gully erosion by the construction of check-dams, vegetative catchment barriers and grass water ways across the gullies in order to reduce the volume of soil loss in the area.
3. Areas that are affected and vulnerable to gully erosion could be allocated to special uses. For example, such vulnerable area could be used for wild life and recreational purposes.

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Appealing Decisions

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for writing a good quality Social Science Research Paper

Techniques for writing a good quality homan social science research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of homan social science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.
Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

19. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

20. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

21. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

22. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

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Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

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Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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