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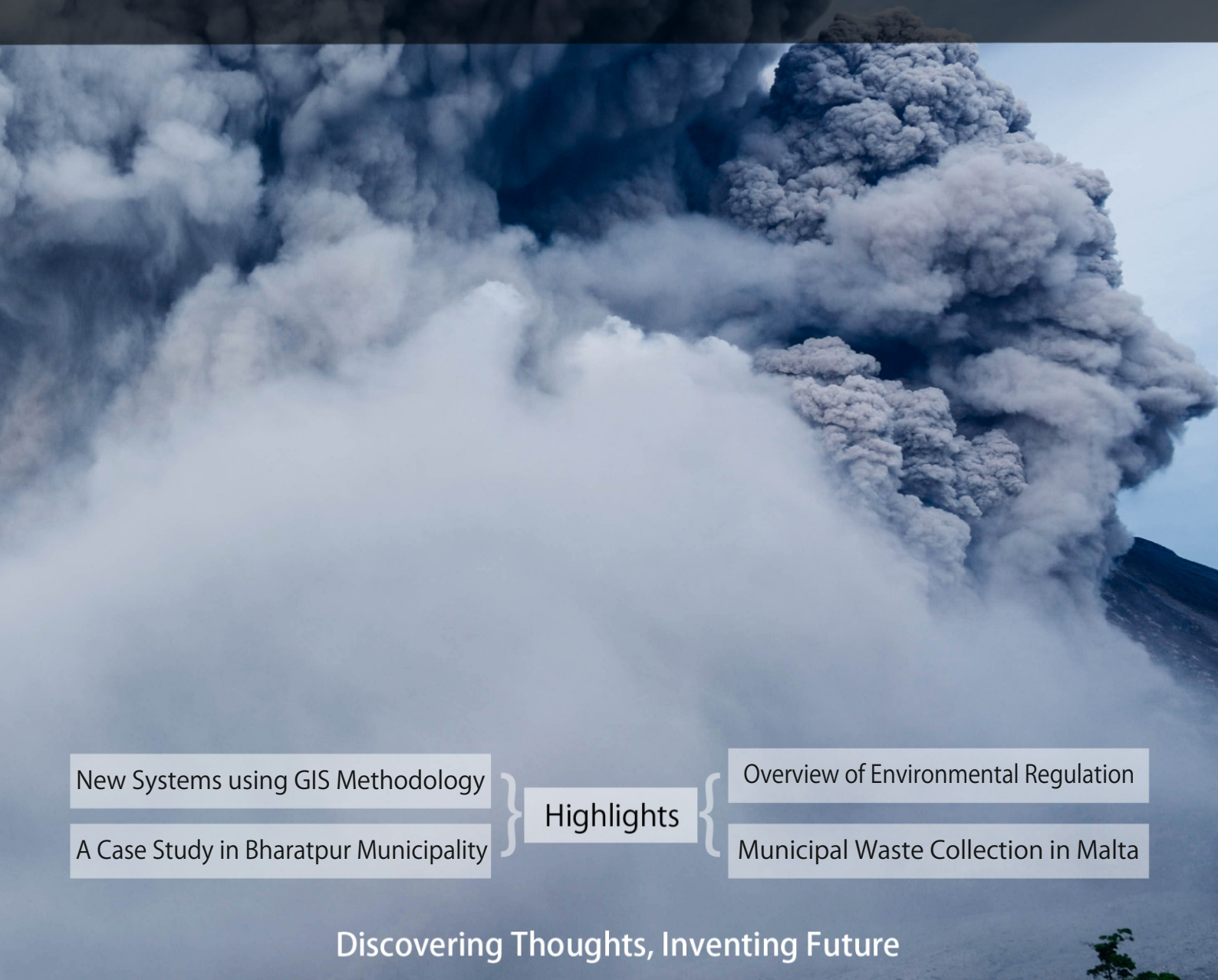

New Systems using GIS Methodology

A Case Study in Bharatpur Municipality

Highlights

Overview of Environmental Regulation

Municipal Waste Collection in Malta

Discovering Thoughts, Inventing Future

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Rerouting Municipal Waste Collection in Malta. An Examination of Waste Collection Routes with Proposed New Systems using GIS Methodology

By Ausiannikava, Liliya, Camilleri-Fenech, Margaret & Bajada, Thérèse
University of Malta

Abstract- Kerbside collection of waste is not often included as part of carbon footprint analysis in view that it constitutes about 5e percent of the carbon emissions generated by the waste collection and treatment systems. However, it also represents the most expensive functional element in the entire waste management process, reaching as high as 75 percent of all costs in the total municipal solid waste (MSW) management system. Most costs relate to fuel, together with labour costs. Fuel consumption results in various pollutants, predominantly carbon dioxide, nitrogen oxides and sulfur dioxide, which are of major concern due to their contribution to global warming and acid rain. In Malta, transport emissions generated from the MSW collection system reach 14 percent of total emissions. This is significantly higher than the European average which generally reaches 5 percent. During the time the study was carried out, the local councils (municipalities) were left to their own devices to sketch a collection route with the result that truck drivers often outline a route simply on their experience.

Keywords: municipal solid waste, collection route, geographic information systems, network analyst, route optimization, transport emissions, carbon dioxide.

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Rerouting Municipal Waste Collection in Malta. An Examination of Waste Collection Routes with Proposed New Systems using GIS Methodology

Ausiannikava, Liliya [α], Camilleri-Fenech, Margaret [σ] & Bajada, Thérèse [ρ]

Abstract- Kerbside collection of waste is not often included as part of carbon footprint analysis in view that it constitutes about 5e percent of the carbon emissions generated by the waste collection and treatment systems. However, it also represents the most expensive functional element in the entire waste management process, reaching as high as 75 percent of all costs in the total municipal solid waste (MSW) management system. Most costs relate to fuel, together with labour costs. Fuel consumption results in various pollutants, predominantly carbon dioxide, nitrogen oxides and sulfur dioxide, which are of major concern due to their contribution to global warming and acid rain. In Malta, transport emissions generated from the MSW collection system reach 14 percent of total emissions. This is significantly higher than the European average which generally reaches 5 percent. During the time the study was carried out, the local councils (municipalities) were left to their own devices to sketch a collection route with the result that truck drivers often outline a route simply on their experience. Therefore, room for improvement is clearly present and it is necessary to find an optimal solution to reduce fuel consumption and minimize emissions. This research uses Geographic Information Systems (GIS) through the Arc GIS Network Analyst application to optimize routes by enhancing the efficiency of waste collection and transportation in the cities of Mellieħa and Attard, Malta. The model that is created is based on data collection involving the Global Positioning System tracking including bin position, (landfill) and collection route as variables. Key performance indicators of the existing practice are estimated. Following this, potential optimal scenarios were developed and compared to the existing collection routes. Results indicate that the proposed scenarios have direct positive impacts on vehicle operating times with operational cost savings and reduced carbon dioxide, nitrogen oxide, and particle emissions.

Keywords: municipal solid waste, collection route, geographic information systems, network analyst, route optimization, transport emissions, carbon dioxide.

I. Introduction

The management of waste consists of several steps which are sequentially performed. Generally, these consist of collection, transport, and treatment either for recycling or reusing purposes or for pre-treatment prior to landfill disposal [1]. Therefore, waste collection, transfer and transport provide a basic function in all waste management systems [2]. A distinction should be made between the three roles played by transport in waste management. Eistad et al., 2009 refer to the collection stage "as the collection of waste by a truck while following a route in a residential or commercial area until the truck is full and/or the collection route ends". Transport, on the other hand, refers to the moving of the full truck to the point of unloading. Transfer then takes place when waste is reloaded and consolidated from small transport units into a large unit using floor or bunker and sometimes in conjunction with compression, wrapping, or sorting. Following the transfer, waste is transported by means of a train, a tractor-trailer unit or a barge depending on the origin, destination, and type of waste [3].

Municipal Waste Management (MSW) incorporates several interrelated aspects which need complete cooperation and collaboration for an efficient delivery [4]. Additionally, the management of this type of waste is one of the most challenging in view that it involves the public and therefore it allows for the generator to frequently meet the waste management representatives [[5].

This research is focused on the collection phase MSW. collection. This is, in fact, the most expensive functional element in the entire waste management process, reaching as high as 85 percent of all costs in the total MSW management system. Most of these costs are fuel related since solid waste collection processes are mainly carried out by utilizing trucks with fuels [4]. Furthermore, the trucks emit pollutants into the atmosphere, predominantly carbon dioxide, nitrogen oxides and sulphur dioxide, that are toxic for human beings and cause acid rain and global warming.

In Malta, a carbon footprint study noted that the introduction of a separate organic waste collection and facilities like a mechanical biological treatment plant leads to substantial savings in GHG emissions, however, transport emissions reach 14 percent of total emissions which is significantly higher than the European average which generally reaches 5 percent [6]. The same research, noted that currently there is no fixed collection route for waste collection. Routes are left to the drivers who devise a route simply on their experience. Often, however, routes change according to

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the driver resulting in a change of schedule in the waste collected. Additionally, no form of optimization is present and therefore room for improvement is clearly present. Therefore, the problem requires a quantitative and subjective approach instead of relying on the perceptions of drivers. Route optimization is one of the most common measures undertaken to reduce GHG emissions in relation to collection and transport [7]. Furthermore, the optimization of routes, together with developing courses which are better suited for a particular locality's needs, leads to a reduction in collection time by 10 to 15 minutes [8].

II. Materials and Methods

The methodology structure that is used in this research, consists of four general steps:

- Fieldwork Study and Data Collection;
- Data analysis;
- Route optimisation and GIS Analyst;
- The evaluation of the performance of the proposed scenarios;

The methodology diagram with a detailed description is shown in Figure 3.

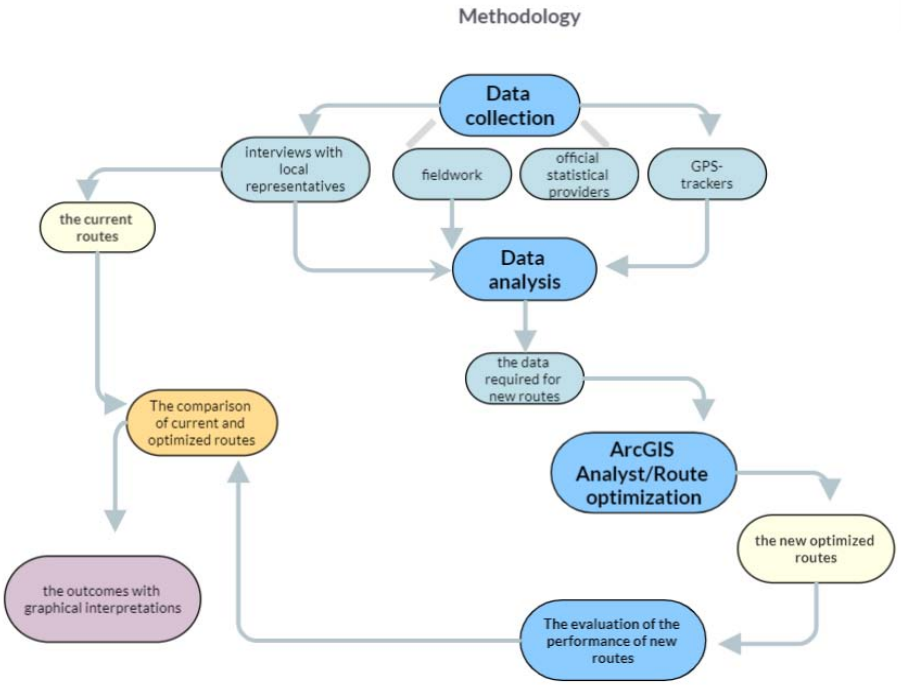

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Figure 1: The Methodology with a Detailed Description

a) Fieldwork Study and Data Collection

In the research, two localities were selected for the pilot study - Mellieħa and Attard due to different topographies: the town of Mellieħa stands on a group of hills on the main island (the estimated terrain elevation above sea level is 150 meters) while the relief of Attard town is mostly flat in nature (the estimate terrain elevation above sea level is 78 meters). Therefore, the two case studies offer different challenges that can then be applied as an example for other localities that have similar topographical characteristics.

Waste collection occurs six days per week except on Sundays. It includes the collection of organic, recyclable, and mixed waste. The same route is used for the collection of different types of waste. In the research, the collection route for mixed waste is analyzed. Mixed waste collection takes place on Tuesday and Saturday.

An overview of waste management practices in Mellieħa and Attard is required to enhance the efficiency of the collection of MSW. Waste management data was collected for the period January 2021 - January 2022=. Maps from local municipalities, digital data from various official providers including the Malta National Statistics Office, ArcGIS Business Analyst and WasteServ Malta Ltd, interviews/meetings with local council representatives and fieldwork were the main data sources used for the route optimization. ArcGIS Business Analyst provides an overview of waste typology sectors. However, this information is not used in the calculations. This source was used in the research since it was difficult to obtain the information from official providers.

Detailed interviews with the local council representatives of Attard and Mellieħa were conducted

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to gain a deeper understanding of the MSW collection practices in two localities, methods and modes of waste transportation and collection, number, type and capacity of vehicles, schedule of transportation and collection waste, vehicles staff in the municipal solid waste collection process teams of the two cities.

Existing solid waste collection routes were obtained by GPS trackers Garmin GPSmap62 that were placed in waste collection vehicles. GPS tracker Garmin has high-sensitivity and helix antenna, WAAS/EGNOS-enabled GPS receiver with HotFix® satellite prediction, GPSMAP 62 has unparalleled reception to determine the position precisely and quickly and maintains its GPS location (95 % accuracy) [9].

Each street was checked and analysed in terms of one/two- way movement while doing fieldwork. Both localities were visited more than 15 times during summer, winter and autumn to observe the traffic situation and waste collection process. The collected data is presented in Table 1.

Table 1: Collected Data for Route Optimisation in Attard and Mellieħa

Collected Data	Source of Data	Website
road networks and characteristics of the streets (width, length, one/two-way), geographical boarders;	maps from local municipalities, fieldwork.	*Online Database: https:// workflow.gov.mt/*
traffic situation;	fieldwork, ArcGIS traffic service;	
characteristics of the current municipal waste collection practices;	interview/meeting with local council representatives.	
the current waste collection routes (their distance and time);	GPS trackers Garmin GPS map62;	
population size, population density, total households, household size;	The Malta Statistics Office;	https://msa.gov.mt /
waste characteristics, waste typology sectors, waste generation rate;	WasteServ Malta Ltd (the company responsible for the waste collection service), ArcGIS Business Analyst;	https://wsm.com.mt/
type and number of collection vehicles; vehicle capacity and average fuel consumption;	interview/meeting with local council representatives.	

Source: Authors'' own

b) Data Analysis

To achieve the aim of the research, "to examine the current routes utilized in two localities of Malta for MSW collection and then use Geographic Information Systems (GIS) to optimize the present collection system," the following actions were taken:

1. *Statistical Analysis of Demographic and Waste Data:* Population size, population density, total households, household size, waste characteristics, and waste generation were statistically analyzed to understand the factors influencing waste generation and collection needs. This comprehensive analysis helped identify key demographic and waste factors crucial for optimizing the waste collection routes.
2. *Measurement of Street Characteristics:* The length and width of streets were manually measured using Google Maps, and each street was analyzed individually. Based on these measurements, streets were categorized as passable, non-passable, and occasionally impassable. This categorization provided essential information for routing analysis, ensuring that routes could accommodate collection vehicles efficiently. Moreover, turn delays, restricted turns, temporary road closures, and dead ends were analyzed.
3. *Traffic Data Collection and Analysis:* A web map of traffic provided by ArcGIS was utilized, offering near-real-time and historical traffic data feeds.

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Additionally, traffic conditions were observed directly during fieldwork to assess real-time situations and historical trends. This traffic analysis was vital for minimizing delays and optimizing route efficiency by incorporating realistic traffic patterns.

4. *Mapping Existing Waste Collection Routes:* Existing solid waste collection routes and the location of the landfill were mapped using GPS trackers (Garmin GPSmap62). The routes were divided into segments based on destination points. For instance, Figure 2 demonstrates an example of route classification in Attard, providing a clear visualization of existing waste collection paths and their segmentation.

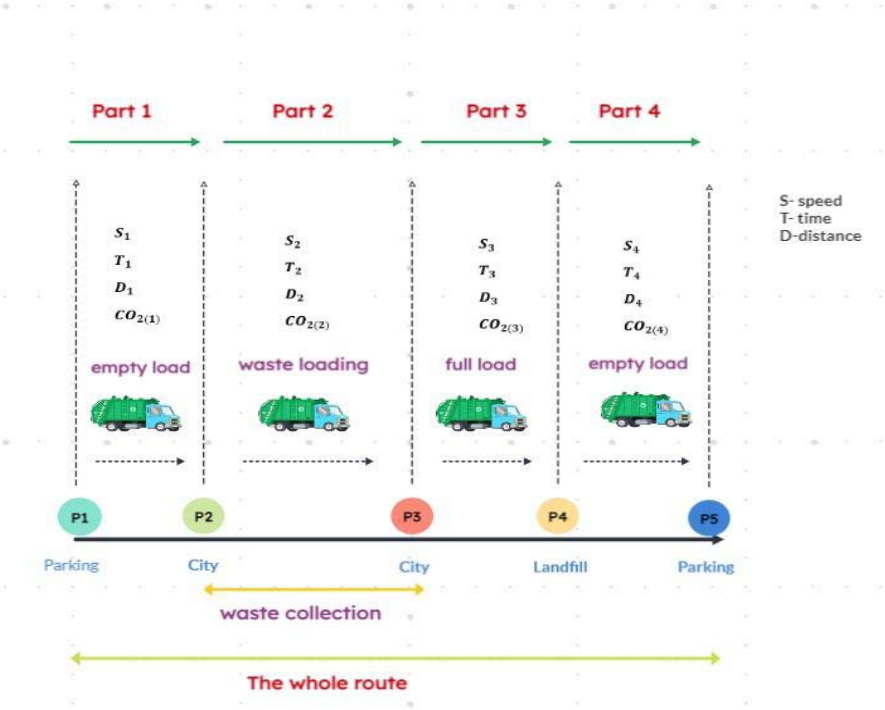

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Figure 2: Route Classification based on the Destination Points in Attard

5. *Calculation of Speed Mode, Emissions, and Fuel Consumption:* Speed mode, travel time and distance, fuel consumption, and emissions of carbon dioxide (CO_2), nitrogen oxides (NO_x), and particulate matter (PM) were calculated for each segment of the route. These calculations were based on the road type and truckload level. Since fuel consumption changes incrementally depending on the truck's load, higher loads typically result in greater fuel consumption, leading to varying levels of CO_2, NO_x, and PM emissions. The following formula (Figure 3) was used to calculate average speed.

$$s = \frac{d}{t} \quad (1)$$

Figure 3: Speed formula.

where is s= speed, d= distance travelled, t= time elapsed.

6. *Topography Consideration:* Topography was considered in fuel consumption calculations. Attard, being mostly flat, has a lower fuel consumption rate (28 liters per 100 km) compared to Mellieħa (30 liters per 100 km), which is situated on a group of hills. Fuel consumption data from Volvo Truck Corporation, based on road type and load level, was used to adjust fuel consumption rates in both localities, factoring in topography, load level, and road type (Tables 2 and 3).

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Table 2: The Rates of Fuel Consumption in Mellieħa.

Route Name	Level of Load	The Type of the Road	The Rate of Fuel
segment 1	empty load	arterials, distributors	27
Segment 2	loading	local access roads.	30
segment 3	full load	arterials, distributors	35
segment 4	loading	local access roads.	30
segment 5	full load	arterials, distributors	35
segment 6	empty load	arterials, distributors	27

Table 3: The Rates of Fuel Consumption in Attard.

Route Name	Level of Load	The Type of the Road	The Rate of Fuel
segment 1	empty load	arterials, distributors	27
segment2	loading	local access roads.	28
segment 3	full load	arterials, distributors	35
segment 4	empty load	arterials, distributors	27

7. *Traffic Congestion Consideration:* Traffic congestion was also considered in fuel consumption estimates. In congested traffic, vehicles typically burn between 0.6 to 1.2 liters of fuel per hour [10]. The congested streets in Attard include Triq Il-Pitkali, Triq in-Nutar Zarb, Triq iż-Żagħfran, Triq Il-Mosta, Triq Is-Salina, Triq Il-Fortizza Tal-Mosta (partly), and Triq Tal-Labour at 6:30 a.m. In Mellieħa, the congested streets are Triq il-Mellieħa, Triq Il-Marfa, Triq Il-Kbira, Triq Qasam Barrani, and Tul Il-Kosta at 6:30 a.m. Due to these traffic conditions, an additional 0.8 liters were added to the total fuel consumption in Attard, while one liter was added in Mellieħa.

c) Route optimszation and GIS Analyst

Geographic Information Systems (GIS) are sophisticated information systems used for tracking, managing, analysing, presenting, and storing data with a spatial distribution. GIS includes a spatially geo-referenced database that encompasses the critical parameters necessary for effective solid waste management [11]. These parameters include the locations of landfills, city maps, transportation and collection road networks, and transfer stations [12]. GIS provides a powerful tool for optimising solid waste management by integrating diverse spatial data and offering robust analytical capabilities. Its ability to enhance decision-making through spatial analysis, efficient routing, and scenario planning makes it indispensable for modern waste management strategies [11].

The route optimisation process included several key steps. The first step was the determination of collection points, which were generated based on the streets where waste collection occurs, ensuring comprehensive coverage of the service area. Secondly, the location of the landfill was identified, serving as the primary disposal point for the collected waste. Thirdly, the start and end points of each route were established to facilitate efficient waste collection operations. Additionally, the starting times for each route were selected to optimise traffic flow.

Traffic situations and road networks were analyzed using ArcGIS, incorporating both historical and real-time traffic data to minimise delays. The optimised routes were then determined using the Network Analyst extension in the GIS application. Routes were simulated multiple times, considering temporary road closures and non-passable streets. The use of non-passable streets was minimised to ensure optimal vehicle movement.

The selection criteria for the most optimised routes were determined based on specific segments of the route, considering the optimal time-to-distance ratio and minimization of travel time. Stop points were automatically allocated by the GIS application using the Network Analyst extension. Each collection point represented a specific address, but the actual addresses were modified to protect data privacy.

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In summary, the route optimisation process ensured efficient waste collection through a structured methodology incorporating GIS analysis and the Network Analyst extension. This approach minimised delays and improved route efficiency while adhering to privacy regulations.

d) The Evaluation of the Performance of the Proposed Scenarios

The analysis output provided comprehensive data on travel time, distance, and stop frequency. Daily and annual computations were conducted to ascertain the aggregate emissions of CO_2, nitrogen oxides, and particulates. Annual expenses were computed based on 314 operational days in 2022, factoring in the absence of waste collection on Sundays. Furthermore, seasonal variations in fuel consumption were considered, with an anticipated increase during summer (by up to 1 litre), attributed to heightened waste generation. Conversely, in Attard, a decrease of up to 1 litre during winter, autumn, and spring was observed due to GPS tracker implementation in August. Mellieħa exhibited a similar trend with fuel consumption escalation during summer, following GPS tracker installation in November.

A comparative analysis was conducted between proposed and current routes, evaluating enhancements in daily and annual travel metrics. Potential reductions in fuel consumption were examined, consequently leading to decreased emissions of CO_2, nitrogen oxides, and particulates.

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

III. Results

This section presents the development of new collection routes in two localities in Malta in detail including their evaluation and the comparisons with the existing collection routes.

The data was collected using GPS trackers Garmin GPSmap62, through fieldwork and face-to-face interviews with the local council representatives of Attard and Mellieħa.

a) Route Modeling for the Optimisation of Waste Collection and Transportation in Mellieħa

i. Proposed Scenario in Mellieħa and Assessment of its Performance

Based on travel mode (trucking time), traffic data and restrictions adopted in ArcGIS Network Analyst, such as temporary road closure during schooling time, turn delays and restricted turns, optimal routes are developed. Figure 4 represents the optimised route for the second segment of the route. While Figure 5 indicates the total route in Mellieħa. Optimised routes for the 5 segments of the route are shown in Appendix A. The detailed route is described in Appendix B.

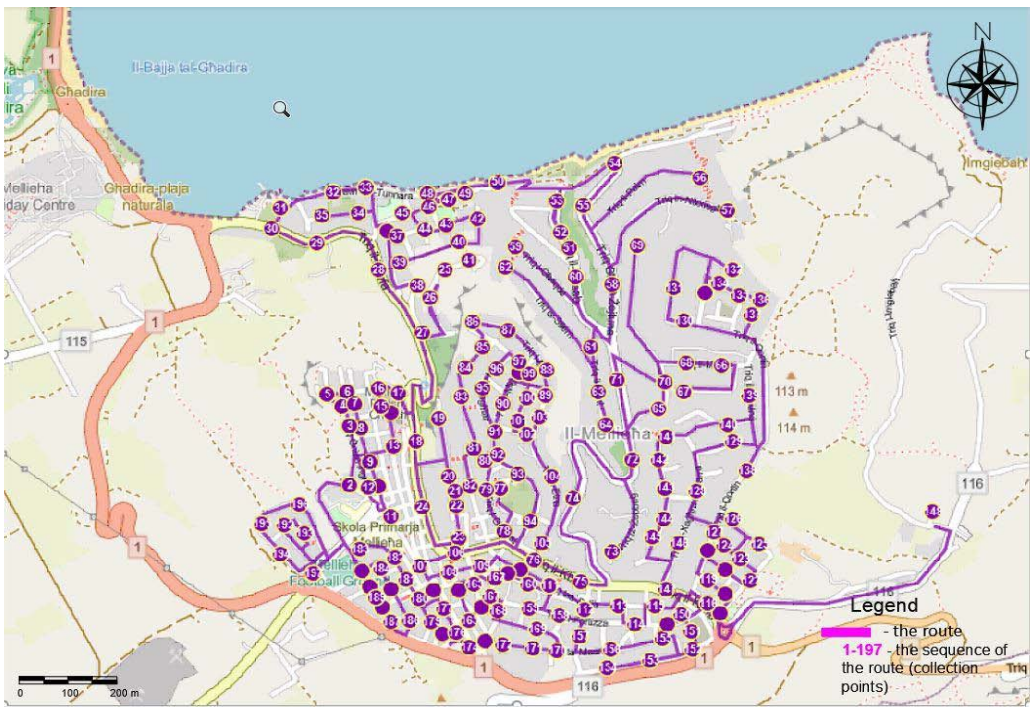

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Figure 4: The Second Segment of the Optimized Route in Mellieħa

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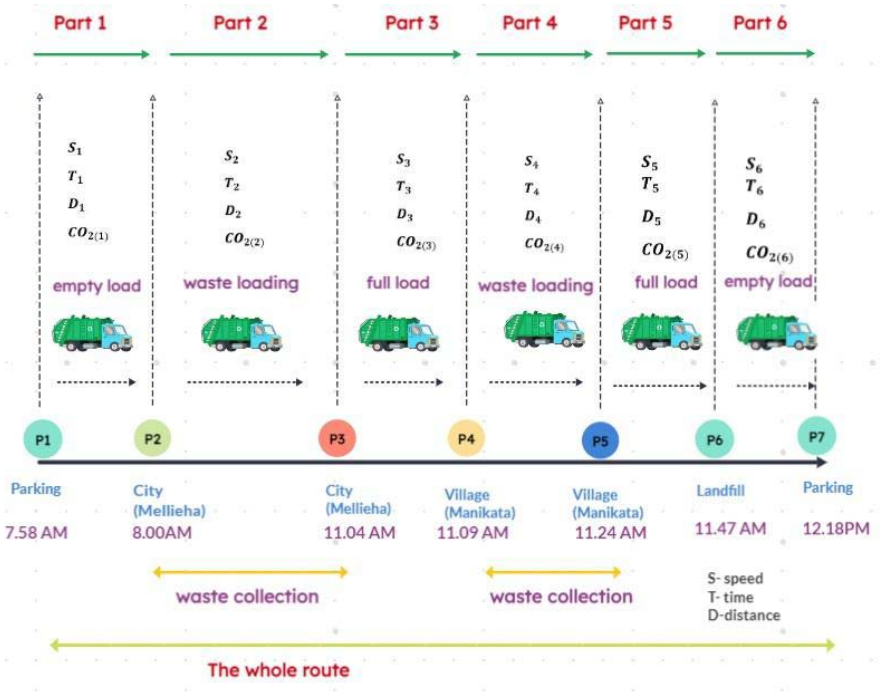

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Figure 5: The proposed route in Mellieħa

Travelled time, distance and the number of stops were obtained in the output of analysis. The data regarding the segments of the route are shown in Table 4. Overall traveling time and distance, as well as the number of stops along the route, were computed as the sum of route segments, while average speed was determined as the mean of route segments. The total duration of the route is 4 hours 21 minutes including 3 minutes at the landfill. The total distance is 66.75 km.

Table 4: The Calculations of the Proposed Scenario in Mellieħa

Route Name	Stop Count	Time (Minutes)	Distance (Kilometers)	Average Speed
Segment 1	2	2	0.688	20
Segment 2	195	184	36.97	12
Segment 3	2	5	2.24	26.88
Segment 4	2	15	2.42	9.6
Segment 5	2	23	11.2	29
Segment 6	2	28	13.24	28
Total route	205	257	66.75	20.4

Source: Authors' own

The amount of fuel consumed varies significantly depending on traffic conditions, road types, driving style, and the vehicle's load level. Fuel consumption and emissions were calculated based on the values for Volvo engines, as presented in Appendix C. The total fuel consumption for the route is 21.17 liters (Table 5). The corresponding emissions include 55.04 kg of CO_2, 148.19 g of nitrogen oxides, and 2.12 g of particulate matter.

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Table 5: Fuel Consumption and Emission Calculations of the Proposed Scenario in Mellieħa.

Route Name	Level of Load	Distance (kilometers)	Fuel Consumption	CO2 kg/litre	NOx g/litre	PM g/litre
Segment 1	empty load	0.688	0.19	0.48	1.30	0.02
Segment2	loading	36.97	11.00	28.60	77.00	1.10
Segment 3	full load	2.24	0.78	2.04	5.49	0.08
Segment 4	loading	2.42	0.70	1.82	4.90	0.07
Segment 5	full load	11.2	4.40	11.44	30.80	0.44
Segment 6	empty load	13.24	4.10	10.66	28.70	0.41
Total route		66.758	21.17	55.04	148.19	2.12

Source: Authors' own

ii. *The Comparison of Current and Optimised Routes in Mellieħa*

The current waste collection route distance in Mellieħa is 78.4 km and the time needed is 5 hours 18 minutes while the proposed collection route length is 66.7 km and the time needed is 4 hours 17 minutes. The current route of waste collection in Mellieħa covers a total of 24,617 kilometers and 99,852 minutes annually while the proposed route is 20,943 kilometers and 80,698 minutes annually. Thus, the proposed route will save up to 3,673 kilometers and 19,154 minutes annually (15 percent and 19 percent improvements compared to the current route).

The current route fuel consumption is 25.03 litres per day while the proposed route fuel consumption is 21.7 litres per day. Annual fuel consumption reaches up to 7,859 litres whereas the proposed route burns 6,647 litres of fuel. Hence, the potential savings are 1,212 litres of fuel annually.

Carbon dioxide, nitrogen oxides, and particulates are formed by the combustion of fuel. The amount of carbon dioxide, nitrogen oxide, and particulates produced by the current route is 65.07 kg; 175.18 g and 2.5 g respectively while the proposed route produces 55 kg of carbon dioxide, 148 g of nitrogen oxide and 2.1 g of particulates. The emissions of carbon dioxide, nitrogen oxide, and particulates reach 20,413 kg; 55,006 g; and 785 g annually by the current route whereas the proposed route emits 17,282 kg of carbon dioxide, 46,531 g of nitrogen oxide and 665 g of particulates on annual basis. Subsequently, the application of the proposed route will lead to the saving of 3,149 kg of carbon dioxide, 8,474 g of nitrogen oxide and 119.3 g of particulates reduction annually (up to 15 percent improvement compared to the current route). Detailed calculations are provided in Tables 6-7.

Table 6: The Comparison of Current and Proposed Routes in Mellieħa for Time and Distance Criteria.

	Route Name	Time (minutes)	Distance (kilometers)
Current route	Segment 1	2	0.688
	Segment2	240	46.85
	Segment 3	4	2.24
	Segment 4	15	2.42
	Segment 5	22	11.28
	Segment 6	35	14.95
	Total route	318	78.428
	Route Name	Time (minutes)	Distance (kilometers)
proposed route	Segment 1	2	0.688
	Segment2	184	36.97
	Segment 3	5	2.24
	Segment 4	15	2.42
	Segment 5	23	11.2
	Segment 6	28	13.24
	Total route	257	66.758

Source: Authors'' own

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Table 7: The comparison of current and proposed routes in Mellieħa for time, distance, fuel consumption and emission criteria.

	Current Route	Proposed Route	Improvement from Current Route	Improvement on Current Route %
Distance(km), day	78.4	66.7	11.7	15
Distance(km), year	24617.6	20943.8	3673.8	15
Time (min), day	318	257	61	19
Time (min), year	99852	80698	19154	19
Fuel Consumption(litre), day	25.03	21.17	3.86	15
Fuel Consumption(litre), year	7859.42	6647.38	1212.04	15
CO2 kg/litre, day	65.07	55.04	10.03	15
CO2 kg/litre, year	20431.98	17282.56	3149.42	15
NOx g/litre, day	175.18	148.19	26.99	15
NOx g/litre, year	55006.52	46531.66	8474.86	15
PM g/litre, day	2.5	2.12	0.38	15
PM g/litre, year	785	665.68	119.32	15

Source: Authors' own

b) *Route Modeling for the Optimization of Waste Collection and Transportation in Attard*

IV. Discussion

EconEconomic growth, rapid urbanisation, population growth, and improved community living standards have significantly accelerated the rate of waste generation worldwide. Malta faces a demographic challenge that could affect economic growth and fiscal spending for the next two decades. The percentage of the population aged 65 and older is increasing, while the percentage of those aged 0-14 is decreasing. Additionally, Malta has experienced steady economic growth due to its favorable tax environment. If progressive immigration policies are implemented and economic growth continues at the current rate, the population is projected to increase by 60% over the next seventeen years, leading to higher consumption and greater waste generation.

Local municipalities are generally responsible for waste management in cities, struggle to provide effective systems for residents. They often face problems that exceed their capacity due to a lack of organization, financial resources, and the complexity of the system. Waste collection is the most expensive component of the waste management process, accounting for up to 75% of total costs in the Municipal Solid Waste (MSW) management system. Most of these costs are related to fuel consumption, as solid waste collection is primarily carried out by fuel-powered trucks. These trucks emit pollutants into the atmosphere, predominantly carbon dioxide, nitrogen oxides, and sulfur dioxide, which are toxic to humans and contribute to acid rain and global warming.

The aim of this research was to analyse the current routes used in two localities of Malta for Municipal Solid Waste collection and then leverage GIS to optimise the existing collection system. To accomplish this aim, a comprehensive methodology was developed encompassing four main steps: fieldwork study and data collection, data analysis, GIS analysis and route optimization, and evaluation of the proposed scenarios' performance.

Data was collected using Garmin GPSmap62 GPS trackers, fieldwork, and face-to-face interviews with local council representatives in Attard and Mellieħa. The optimised routes were determined using ArcGIS and the Network Analyst extension, taking into account road restrictions, traffic conditions, and street characteristics. Travel distance, time, fuel consumption, and emissions were calculated based on the load levels of the trucks. The application of Network Analyst demonstrated substantial cost savings by reducing fuel expenses, kilometers driven, and total travel time.

In Attard, the current waste collection route covers 44.1 km and requires 3 hours and 44 minutes daily, while the proposed collection route spans 37.73 km and takes 2 hours and 56 minutes. Thus, the proposed route will save up to 2,000 kilometers and 15,072 minutes annually, representing a 14% reduction in distance and a 21% improvement in time compared to the current route. The proposed route will result in annual savings of 593 liters of fuel and reduce emissions by 1,545 kg of carbon dioxide, 4,161 g of nitrogen oxide, and 59 g of particulates.

In Mellieħa, the current waste collection route covers 78.4 km and takes 5 hours and 18 minutes daily, while the proposed collection route spans 66.7 km and

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requires 4 hours and 17 minutes. Consequently, the proposed route will save up to 3,673 kilometers and 19,154 minutes annually, representing a 15% reduction in distance and a 19% improvement in time compared to the current route. The proposed route will result in annual savings of 1,212 liters of fuel and reduce emissions by 3,149 kg of carbon dioxide, 8,474 g of nitrogen oxide, and 119.3 g of particulates.

In summary, the route optimization was successfully achieved in both localities. The results clearly demonstrate that the proposed routes are more efficient in terms of collection time and distance traveled. These improvements are directly correlated with decreased fuel consumption, leading to a reduction in carbon dioxide, nitrogen oxide, and particulate emissions.

V. Conclusions and Recommendations

This research effectively optimized waste collection routes in two localities of Malta using GIS. The findings unequivocally indicate that the proposed routes are more efficient in terms of collection time and distance traveled. These improvements are highly correlated with decreased fuel consumption, leading to a significant reduction in carbon dioxide, nitrogen oxide, and particulate emissions.

Based on the findings of this research, the following recommendations are proposed to enhance the efficiency of waste collection in Malta:

Waste Collection Schedule: Traffic congestion was observed during fieldwork, particularly in the morning, creating significant difficulties for residents and vehicles and hindering efficient waste collection. Shifting the waste collection schedule to evening or nighttime hours could improve efficiency by avoiding traffic jams and minimizing the negative impact of leaving waste outside for extended periods. Spain is an example of a country that collects waste efficiently in the evening or night.

Utilising ArcGIS Network Analyst Extension: ArcGIS, with its Network Analyst extension, is a valuable tool for route optimization. Applying this tool could improve the efficiency of not just municipal solid waste collection but also construction waste collection. Other types of waste collection can also be considered.

Adaptability of the Models: The proposed models are highly adaptable and could be applied in various locations within the country and beyond, particularly in developing countries facing significant challenges in solid waste management. However, accurate knowledge of the waste generation rate, road network, and road restrictions is required to achieve optimal results.

Practical Applications: The research offers a straightforward decision to the current problem. The models that were developed in the research have practical applications. It is expected that local municipalities will consider the results of the research physically and empirically while making decisions regarding the waste collection process.

Future Research Directions

Multiple Truck Routes: Developing routes using multiple trucks could increase the efficiency of the waste collection process. However, this recommendation depends on the budget allocated for waste collection, as utilising multiple trucks may be more expensive than using a single truck.

Evening or Night-Time Optimisation: The proposed models could be modified and simulated for evening or nighttime hours. This shift would enhance the performance of the waste collection process by avoiding congestion.

Author Contributions: Conceptualization, M.C. –F. and L.A.; methodology, L.A.; software, L.A.; validation, M.C. -F.; resources, M.C. -F.; data curation, L.A.; writing—original draft preparation, L.A.; writing-review and editing, M.C. -F.; visualization, L.A.; supervision, M.C. -F.; project administration, M.C. –F. T.B. writing review. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflicts of interest.

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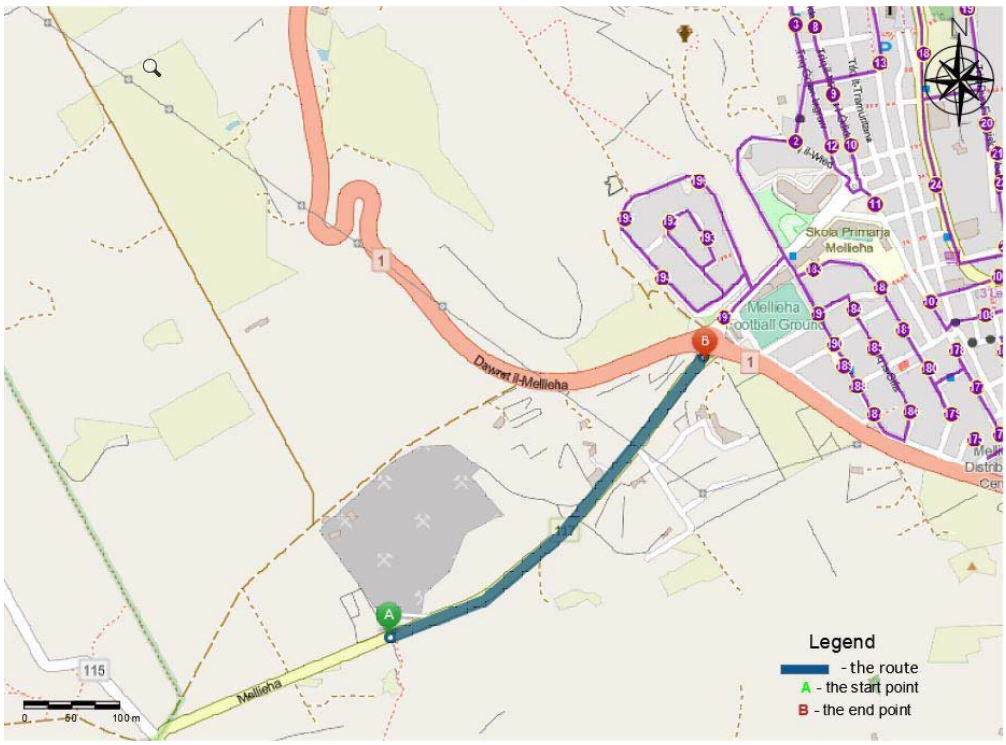
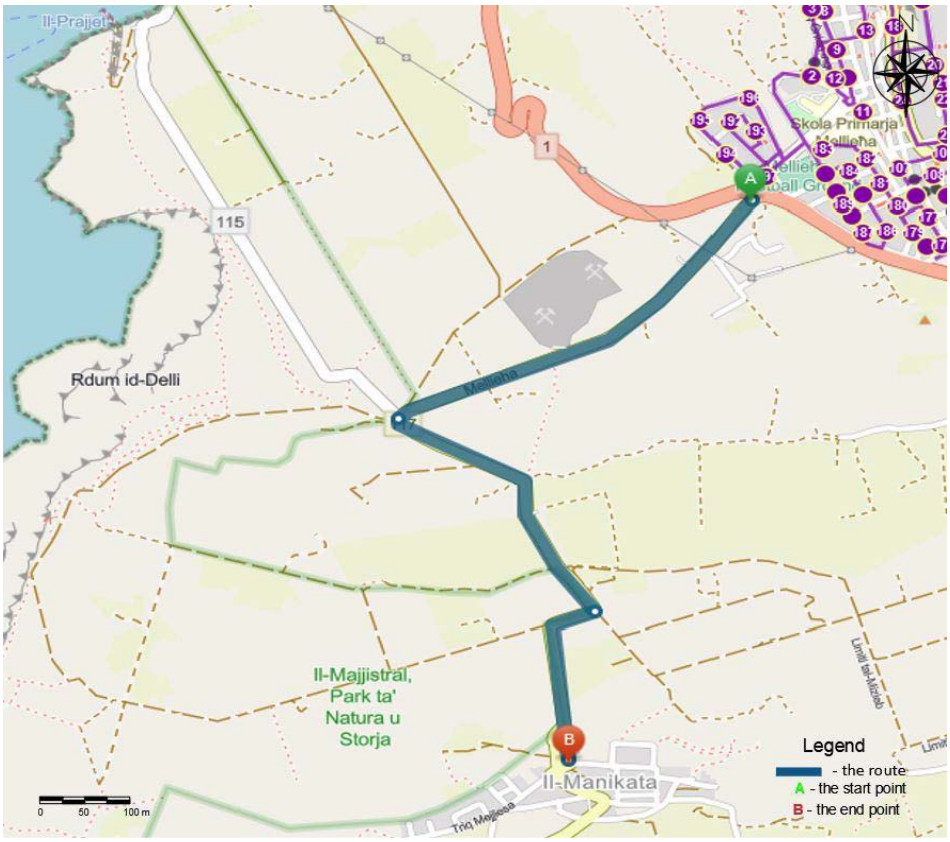
Appendix A



Source: Authors' own

Figure A1: The First Segment of the Optimized Route in Mellieħa



Source: Authors' own

Figure A2: The Third Segment of the Optimized Route in Mellieħa

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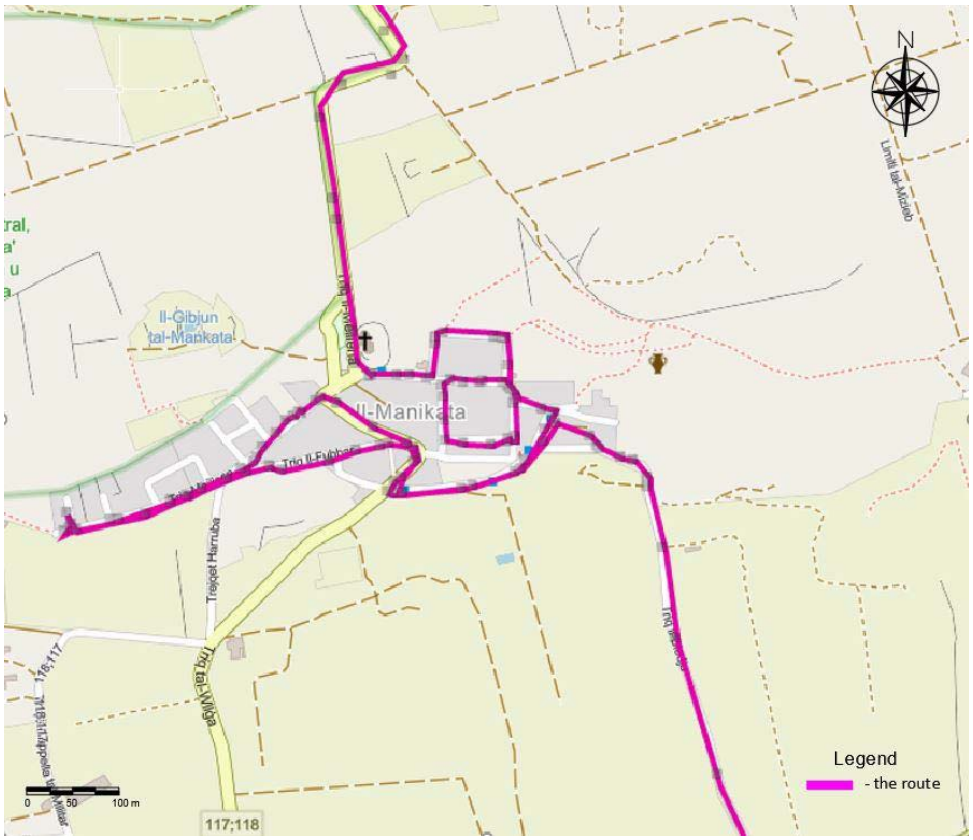
N
Il-Qibjun tal-Mankata
Il-Manikata
Triq il-Fulbiena
Triq il-Fulbiena
Triq il-Mankata
Triq il-Mankata
Triqet Harruba
Triq il-Mankata
Triq il-Mankata
Triq il-Mankata



Source: Authors' own

Figure A5: The Sixth Segment of the Optimized Route in Mellieħa

Appendix B

Table B1: The Proposed Route in Mellieħa.

Route Name	Sequence	Travel Distance from Previous Stop (Kilometers)	Address
Start Depot - 1 - Route1	1	0	Address 1
Start Depot - 1 - Route1	2	0.43583	Address 2
Start Depot - 1 - Route1	3	0.19057	Address 3
Start Depot - 1 - Route1	4	0.07226	Address 4
Start Depot - 1 - Route1	5	0.06558	Address 5
Start Depot - 1 - Route1	6	0.06372	Address 6
Start Depot - 1 - Route1	7	0.05423	Address 7
Start Depot - 1 - Route1	8	0.07942	Address 8
Start Depot - 1 - Route1	9	0.11259	Address 9
Start Depot - 1 - Route1	10	0.0854	Address 10
Start Depot - 1 - Route1	11	0.10931	Address 11
Start Depot - 1 - Route1	12	0.14212	Address 12
Start Depot - 1 - Route1	13	0.23691	Address 13
Start Depot - 1 - Route1	14	0.10184	Address 14
Start Depot - 1 - Route1	15	0.04496	Address 15
Start Depot - 1 - Route1	16	0.06632	Address 16
Start Depot - 1 - Route1	17	0.07825	Address 17
Start Depot - 1 - Route1	18	0.17582	Address 18
Start Depot - 1 - Route1	19	0.29804	Address 19
Start Depot - 1 - Route1	20	0.18468	Address 20
Start Depot - 1 - Route1	21	0.05987	Address 21
Start Depot - 1 - Route1	22	0.0471	Address 22
Start Depot - 1 - Route1	23	0.10133	Address 23
Start Depot - 1 - Route1	24	0.22883	Address 24
Start Depot - 1 - Route1	25	0.9564	Address 25

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Start Depot - 1 - Route1	26	0.0492	Address 26
Start Depot - 1 - Route1	27	0.20551	Address 27
Start Depot - 1 - Route1	28	0.29058	Address 28
Start Depot - 1 - Route1	29	0.27474	Address 29
Start Depot - 1 - Route1	30	0.15214	Address 30
Start Depot - 1 - Route1	31	0.06624	Address 31
Start Depot - 1 - Route1	32	0.1728	Address 32
Start Depot - 1 - Route1	33	0.1015	Address 33
Start Depot - 1 - Route1	34	0.13441	Address 34
Start Depot - 1 - Route1	35	0.11152	Address 35
Start Depot - 1 - Route1	36	0.26123	Address 36
Start Depot - 1 - Route1	37	0.06373	Address 37
Start Depot - 1 - Route1	38	0.24963	Address 38
Start Depot - 1 - Route1	39	0.16911	Address 39
Start Depot - 1 - Route1	40	0.19214	Address 40
Start Depot - 1 - Route1	41	0.03327	Address 41
Start Depot - 1 - Route1	42	0.10485	Address 42
Start Depot - 1 - Route1	43	0.1233	Address 43
Start Depot - 1 - Route1	44	0.0775	Address 44
Start Depot - 1 - Route1	45	0.08821	Address 45
Start Depot - 1 - Route1	46	0.08391	Address 46
Start Depot - 1 - Route1	47	0.06388	Address 47
Start Depot - 1 - Route1	48	0.08458	Address 48
Start Depot - 1 - Route1	49	0.11594	Address 49
Start Depot - 1 - Route1	50	0.2616	Address 50
Start Depot - 1 - Route1	51	0.48044	Address 51
Start Depot - 1 - Route1	52	0.05711	Address 52
Start Depot - 1 - Route1	53	0.10759	Address 53
Start Depot - 1 - Route1	54	0.24538	Address 54
Start Depot - 1 - Route1	55	0.18496	Address 55
Start Depot - 1 - Route1	56	0.49137	Address 56
Start Depot - 1 - Route1	57	1.03836	Address 57
Start Depot - 1 - Route1	58	0.56074	Address 58
Start Depot - 1 - Route1	59	0.61258	Address 59
Start Depot - 1 - Route1	60	0.36105	Address 60
Start Depot - 1 - Route1	61	0.24549	Address 61
Start Depot - 1 - Route1	62	0.50647	Address 62
Start Depot - 1 - Route1	63	0.50511	Address 63
Start Depot - 1 - Route1	64	0.10069	Address 64
Start Depot - 1 - Route1	65	0.23984	Address 65
Start Depot - 1 - Route1	66	0.351	Address 66
Start Depot - 1 - Route1	67	0.28427	Address 67
Start Depot - 1 - Route1	68	0.38975	Address 68
Start Depot - 1 - Route1	69	0.4961	Address 69

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Start Depot - 1 - Route1	70	0.47331	Address 70
Start Depot - 1 - Route1	71	0.27427	Address 71
Start Depot - 1 - Route1	72	0.26031	Address 72
Start Depot - 1 - Route1	73	0.33632	Address 73
Start Depot - 1 - Route1	74	0.67878	Address 74
Start Depot - 1 - Route1	75	0.45007	Address 75
Start Depot - 1 - Route1	76	0.15626	Address 76
Start Depot - 1 - Route1	77	0.30813	Address 77
Start Depot - 1 - Route1	78	0.16551	Address 78
Start Depot - 1 - Route1	79	0.14581	Address 79
Start Depot - 1 - Route1	80	0.09734	Address 80
Start Depot - 1 - Route1	81	0.05901	Address 81
Start Depot - 1 - Route1	82	0.12906	Address 82
Start Depot - 1 - Route1	83	0.30083	Address 83
Start Depot - 1 - Route1	84	0.10242	Address 84
Start Depot - 1 - Route1	85	0.08901	Address 85
Start Depot - 1 - Route1	86	0.10537	Address 86
Start Depot - 1 - Route1	87	0.11773	Address 87
Start Depot - 1 - Route1	88	0.17804	Address 88
Start Depot - 1 - Route1	89	0.07428	Address 89
Start Depot - 1 - Route1	90	0.20845	Address 90
Start Depot - 1 - Route1	91	0.09088	Address 91
Start Depot - 1 - Route1	92	0.08146	Address 92
Start Depot - 1 - Route1	93	0.08682	Address 93
Start Depot - 1 - Route1	94	0.18687	Address 94
Start Depot - 1 - Route1	95	0.63836	Address 95
Start Depot - 1 - Route1	96	0.07883	Address 96
Start Depot - 1 - Route1	97	0.09921	Address 97
Start Depot - 1 - Route1	98	0.05029	Address 98
Start Depot - 1 - Route1	99	0.05749	Address 99
Start Depot - 1 - Route1	100	0.07604	Address 100
Start Depot - 1 - Route1	101	0.07738	Address 101
Start Depot - 1 - Route1	102	0.07216	Address 102
Start Depot - 1 - Route1	103	0.08529	Address 103
Start Depot - 1 - Route1	104	0.21469	Address 104
Start Depot - 1 - Route1	105	0.22405	Address 105
Start Depot - 1 - Route1	106	0.31518	Address 106
Start Depot - 1 - Route1	107	0.12945	Address 107
Start Depot - 1 - Route1	108	0.11933	Address 108
Start Depot - 1 - Route1	109	0.10127	Address 109
Start Depot - 1 - Route1	110	0.14952	Address 110
Start Depot - 1 - Route1	111	0.10166	Address 111
Start Depot - 1 - Route1	112	0.15086	Address 112
Start Depot - 1 - Route1	113	0.12289	Address 113

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Start Depot - 1 - Route1	114	0.11051	Address 114
Start Depot - 1 - Route1	115	0.12509	Address 115
Start Depot - 1 - Route1	116	0.22379	Address 116
Start Depot - 1 - Route1	117	0.0489	Address 117
Start Depot - 1 - Route1	118	0.07935	Address 118
Start Depot - 1 - Route1	119	0.06884	Address 119
Start Depot - 1 - Route1	120	0.11803	Address 120
Start Depot - 1 - Route1	121	0.09702	Address 121
Start Depot - 1 - Route1	122	0.10142	Address 122
Start Depot - 1 - Route1	123	0.0875	Address 123
Start Depot - 1 - Route1	124	0.06865	Address 124
Start Depot - 1 - Route1	125	0.15161	Address 125
Start Depot - 1 - Route1	126	0.11177	Address 126
Start Depot - 1 - Route1	127	0.09985	Address 127
Start Depot - 1 - Route1	128	0.1939	Address 128
Start Depot - 1 - Route1	129	0.24688	Address 129
Start Depot - 1 - Route1	130	0.66543	Address 130
Start Depot - 1 - Route1	131	0.15791	Address 131
Start Depot - 1 - Route1	132	0.31105	Address 132
Start Depot - 1 - Route1	133	0.19159	Address 133
Start Depot - 1 - Route1	134	0.09208	Address 134
Start Depot - 1 - Route1	135	0.07277	Address 135
Start Depot - 1 - Route1	136	0.07394	Address 136
Start Depot - 1 - Route1	137	0.04926	Address 137
Start Depot - 1 - Route1	138	0.54147	Address 138
Start Depot - 1 - Route1	139	0.25462	Address 139
Start Depot - 1 - Route1	140	0.15436	Address 140
Start Depot - 1 - Route1	141	0.20085	Address 141
Start Depot - 1 - Route1	142	0.08969	Address 142
Start Depot - 1 - Route1	143	0.09143	Address 143
Start Depot - 1 - Route1	144	0.09879	Address 144
Start Depot - 1 - Route1	145	0.06878	Address 145
Start Depot - 1 - Route1	146	0.20737	Address 146
Start Depot - 1 - Route1	147	0.17209	Address 147
Start Depot - 1 - Route1	148	1.11101	Address 148
Start Depot - 1 - Route1	149	1.17521	Address 149
Start Depot - 1 - Route1	150	0.0797	Address 150
Start Depot - 1 - Route1	151	0.06385	Address 151
Start Depot - 1 - Route1	152	0.07764	Address 152
Start Depot - 1 - Route1	153	0.13444	Address 153
Start Depot - 1 - Route1	154	0.1364	Address 154
Start Depot - 1 - Route1	155	0.32648	Address 155
Start Depot - 1 - Route1	156	0.16395	Address 156
Start Depot - 1 - Route1	157	0.16442	Address 157

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Start Depot - 1 - Route1	158	0.11654	Address 158
Start Depot - 1 - Route1	159	0.09606	Address 159
Start Depot - 1 - Route1	160	0.17451	Address 160
Start Depot - 1 - Route1	161	0.07295	Address 161
Start Depot - 1 - Route1	162	0.05379	Address 162
Start Depot - 1 - Route1	163	0.09681	Address 163
Start Depot - 1 - Route1	164	0.09133	Address 164
Start Depot - 1 - Route1	165	0.10143	Address 165
Start Depot - 1 - Route1	166	0.06377	Address 166
Start Depot - 1 - Route1	167	0.04451	Address 167
Start Depot - 1 - Route1	168	0.07533	Address 168
Start Depot - 1 - Route1	169	0.16041	Address 169
Start Depot - 1 - Route1	170	0.12242	Address 170
Start Depot - 1 - Route1	171	0.07301	Address 171
Start Depot - 1 - Route1	172	0.09681	Address 172
Start Depot - 1 - Route1	173	0.06027	Address 173
Start Depot - 1 - Route1	174	0.05284	Address 174
Start Depot - 1 - Route1	175	0.08784	Address 175
Start Depot - 1 - Route1	176	0.0619	Address 176
Start Depot - 1 - Route1	177	0.08272	Address 177
Start Depot - 1 - Route1	178	0.06843	Address 178
Start Depot - 1 - Route1	179	0.1398	Address 179
Start Depot - 1 - Route1	180	0.07971	Address 180
Start Depot - 1 - Route1	181	0.07615	Address 181
Start Depot - 1 - Route1	182	0.07677	Address 182
Start Depot - 1 - Route1	183	0.12679	Address 183
Start Depot - 1 - Route1	184	0.16966	Address 184
Start Depot - 1 - Route1	185	0.07024	Address 185
Start Depot - 1 - Route1	186	0.11942	Address 186
Start Depot - 1 - Route1	187	0.11151	Address 187
Start Depot - 1 - Route1	188	0.05454	Address 188
Start Depot - 1 - Route1	189	0.03799	Address 189
Start Depot - 1 - Route1	190	0.03776	Address 190
Start Depot - 1 - Route1	191	0.05416	Address 191
Start Depot - 1 - Route1	192	0.41136	Address 192
Start Depot - 1 - Route1	193	0.1004	Address 193
Start Depot - 1 - Route1	194	0.25263	Address 194
Start Depot - 1 - Route1	195	0.11217	Address 195
Start Depot - 1 - Route1	196	0.16058	Address 196
Start Depot - 1 - Route1	197	0.2599	Address 197

Source: Authors' own through ArcGIS

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Appendix C

Table C1: Emission Factors per Litre Fuel Consumed, Volvo Dennis Eagle 2009.

Typical values, based on certification measurements, for the more common Volvo engines, with EU certification diesel fuel						
Car Standard	Law from	Volvo from	NOx g/litre	PM g/litre	HC g/litre	CO2 kg/litre
Euro 5	2009	2005	7	0.10	0.00	2.6

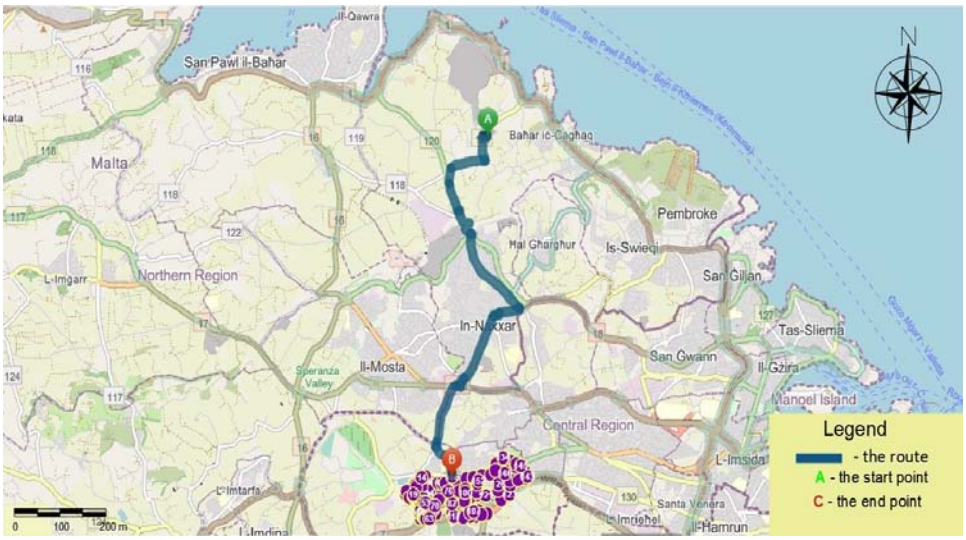
Source: Volvo Trucks, www.volvo.com, accessed 16.12.2023

Table C2: Typical Fuel Consumption in Litres per 100 km, Volvo Dennis Eagle 2009.

	Payload in Tons	Total Weight in Tons	Litres / 100 km Empty	Litre / 100 km Full Load
Truck	14	24	25-30	30-40

Source: Volvo Trucks, www.volvo.com, accessed 16.12.2023

Appendix D



Source: Authors' own

Figure D1: The First Segment of the Optimized Route in Attard.

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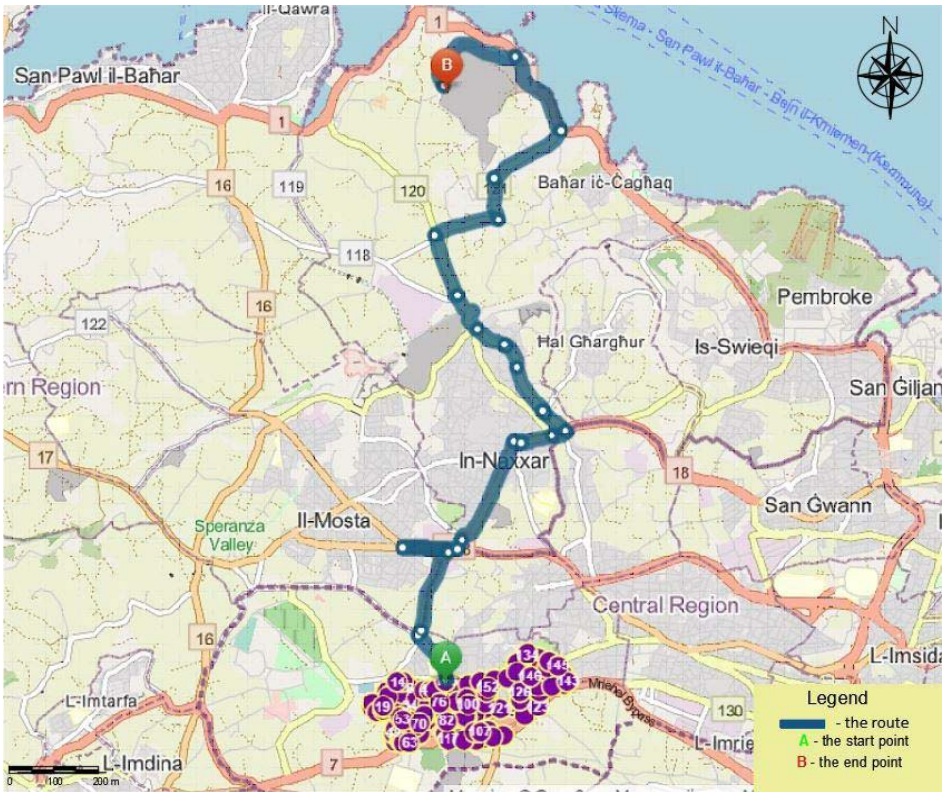

Source: Authors' own

Figure D2: The Third Segment of the Optimized Route in Attard.

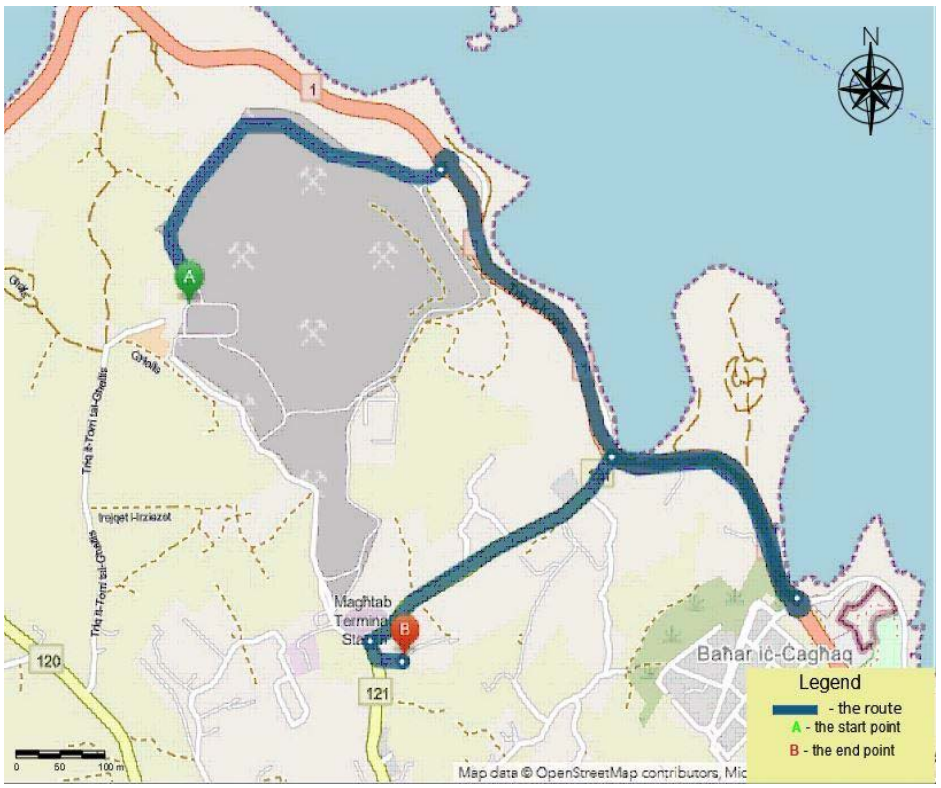

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Figure D3: The Fourth Segment of the Optimized Route in Attard.

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Appendix E

Table E1: The Proposed Route in Attard.

Route Name	Sequence	Travel Distance from Previous Stop (Kilometers)	Address
Start Depot-1-Route 1	1	0	Address 1
Start Depot-1-Route 1	2	0.19	Address 2
Start Depot-1-Route 1	3	0.06	Address 3
Start Depot-1-Route 1	4	0.06	Address 4
Start Depot-1-Route 1	5	0.07	Address 5
Start Depot-1-Route 1	6	0.07	Address 6
Start Depot-1-Route 1	7	0.05	Address 7
Start Depot-1-Route 1	8	0.06	Address 8
Start Depot-1-Route 1	9	0.06	Address 9
Start Depot-1-Route 1	10	0.08	Address 10
Start Depot-1-Route 1	11	0.08	Address 11
Start Depot-1-Route 1	12	0.09	Address 12
Start Depot-1-Route 1	13	0.03	Address 13
Start Depot-1-Route 1	14	0.12	Address 14
Start Depot-1-Route 1	15	0.03	Address 15
Start Depot-1-Route 1	16	0.11	Address 16
Start Depot-1-Route 1	17	0.08	Address 17
Start Depot-1-Route 1	18	0.04	Address 18
Start Depot-1-Route 1	19	0.15	Address 19
Start Depot-1-Route 1	20	0.2	Address 20
Start Depot-1-Route 1	21	0.2	Address 21
Start Depot-1-Route 1	22	0.2	Address 22
Start Depot-1-Route 1	23	0.07	Address 23
Start Depot-1-Route 1	24	0.07	Address 24
Start Depot-1-Route 1	25	0.05	Address 25
Start Depot-1-Route 1	26	0.08	Address 26
Start Depot-1-Route 1	27	0.13	Address 27
Start Depot-1-Route 1	28	0.06	Address 28
Start Depot-1-Route 1	29	0.08	Address 29
Start Depot-1-Route 1	30	0.05	Address 30
Start Depot-1-Route 1	31	0.04	Address 31
Start Depot-1-Route 1	32	0.09	Address 32
Start Depot-1-Route 1	33	0.05	Address 33
Start Depot-1-Route 1	34	0.19	Address 34
Start Depot-1-Route 1	35	0.11	Address 35
Start Depot-1-Route 1	36	0.03	Address 36
Start Depot-1-Route 1	37	0.09	Address 37
Start Depot-1-Route 1	38	0.06	Address 38

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Start Depot-1-Route 1	39	0.04	Address 39
Start Depot-1-Route 1	40	0.14	Address 40
Start Depot-1-Route 1	41	0.05	Address 41
Start Depot-1-Route 1	42	0.1	Address 42
Start Depot-1-Route 1	43	0.04	Address 43
Start Depot-1-Route 1	44	0.12	Address 44
Start Depot-1-Route 1	45	0.14	Address 45
Start Depot-1-Route 1	46	0.05	Address 46
Start Depot-1-Route 1	47	0.06	Address 47
Start Depot-1-Route 1	48	0.06	Address 48
Start Depot-1-Route 1	49	0.09	Address 49
Start Depot-1-Route 1	50	0.07	Address 50
Start Depot-1-Route 1	51	0.19	Address 51
Start Depot-1-Route 1	52	0.04	Address 52
Start Depot-1-Route 1	53	0.04	Address 53
Start Depot-1-Route 1	54	0.02	Address 54
Start Depot-1-Route 1	55	0.03	Address 55
Start Depot-1-Route 1	56	0.04	Address 56
Start Depot-1-Route 1	57	0.07	Address 57
Start Depot-1-Route 1	58	0.02	Address 58
Start Depot-1-Route 1	59	0.03	Address 59
Start Depot-1-Route 1	60	0.06	Address 60
Start Depot-1-Route 1	61	0.03	Address 61
Start Depot-1-Route 1	62	0.03	Address 62
Start Depot-1-Route 1	63	0.04	Address 63
Start Depot-1-Route 1	64	0.04	Address 64
Start Depot-1-Route 1	65	0.07	Address 65
Start Depot-1-Route 1	66	0.07	Address 66
Start Depot-1-Route 1	67	0.2	Address 67
Start Depot-1-Route 1	68	0.02	Address 68
Start Depot-1-Route 1	69	0.1	Address 69
Start Depot-1-Route 1	70	0.04	Address 70
Start Depot-1-Route 1	71	0.12	Address 71
Start Depot-1-Route 1	72	0.08	Address 72
Start Depot-1-Route 1	73	0.02	Address 73
Start Depot-1-Route 1	74	0.09	Address 74
Start Depot-1-Route 1	75	0.09	Address 75
Start Depot-1-Route 1	76	0.03	Address 76
Start Depot-1-Route 1	77	0.15	Address 77
Start Depot-1-Route 1	78	0.06	Address 78
Start Depot-1-Route 1	79	0.2	Address 79
Start Depot-1-Route 1	80	0.12	Address 80
Start Depot-1-Route 1	81	0.03	Address 81
Start Depot-1-Route 1	82	0.03	Address 82

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Start Depot-1-Route 1	83	0.04	Address 83
Start Depot-1-Route 1	84	0.09	Address 84
Start Depot-1-Route 1	85	0.05	Address 85
Start Depot-1-Route 1	86	0.05	Address 86
Start Depot-1-Route 1	87	0.03	Address 87
Start Depot-1-Route 1	88	0.03	Address 88
Start Depot-1-Route 1	89	0.02	Address 89
Start Depot-1-Route 1	90	0.04	Address 90
Start Depot-1-Route 1	91	0.05	Address 91
Start Depot-1-Route 1	92	0.18	Address 92
Start Depot-1-Route 1	93	0.07	Address 93
Start Depot-1-Route 1	94	0.05	Address 94
Start Depot-1-Route 1	95	0.05	Address 95
Start Depot-1-Route 1	96	0.08	Address 96
Start Depot-1-Route 1	97	0.09	Address 97
Start Depot-1-Route 1	98	0.09	Address 98
Start Depot-1-Route 1	99	0.03	Address 99
Start Depot-1-Route 1	100	0.02	Address 100
Start Depot-1-Route 1	101	0.14	Address 101
Start Depot-1-Route 1	102	0.06	Address 102
Start Depot-1-Route 1	103	0.06	Address 103
Start Depot-1-Route 1	104	0.02	Address 104
Start Depot-1-Route 1	105	0.5	Address 105
Start Depot-1-Route 1	106	0.05	Address 106
Start Depot-1-Route 1	107	0.1	Address 107
Start Depot-1-Route 1	108	0.09	Address 108
Start Depot-1-Route 1	109	0.2	Address 109
Start Depot-1-Route 1	110	0.11	Address 110
Start Depot-1-Route 1	111	0.1	Address 111
Start Depot-1-Route 1	112	0.08	Address 112
Start Depot-1-Route 1	113	0.03	Address 113
Start Depot-1-Route 1	114	0.05	Address 114
Start Depot-1-Route 1	115	0.04	Address 115
Start Depot-1-Route 1	116	0.07	Address 116
Start Depot-1-Route 1	117	0.2	Address 117
Start Depot-1-Route 1	118	0.15	Address 118
Start Depot-1-Route 1	119	0.85	Address 119
Start Depot-1-Route 1	120	0.05	Address 120
Start Depot-1-Route 1	121	0.28	Address 121
Start Depot-1-Route 1	122	0.45	Address 122
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Start Depot-1-Route 1	124	0.42	Address 124
Start Depot-1-Route 1	125	0	Address 125
Start Depot-1-Route 1	126	0.09	Address 126

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Start Depot-1-Route 1	127	0.09	Address 127
Start Depot-1-Route 1	128	0.09	Address 128
Start Depot-1-Route 1	129	0.05	Address 129
Start Depot-1-Route 1	130	0.06	Address 130
Start Depot-1-Route 1	131	0.1	Address 131
Start Depot-1-Route 1	132	0.31	Address 132
Start Depot-1-Route 1	133	0.09	Address 133
Start Depot-1-Route 1	134	0.18	Address 134
Start Depot-1-Route 1	135	0.13	Address 135
Start Depot-1-Route 1	136	0.1	Address 136
Start Depot-1-Route 1	137	0.1	Address 137
Start Depot-1-Route 1	138	0.1	Address 138
Start Depot-1-Route 1	139	0.25	Address 139
Start Depot-1-Route 1	140	0.14	Address 140
Start Depot-1-Route 1	141	0.1	Address 141
Start Depot-1-Route 1	142	0.32	Address 142
Start Depot-1-Route 1	143	0.08	Address 143
Start Depot-1-Route 1	144	0.09	Address 144
Start Depot-1-Route 1	145	0.09	Address 145
Start Depot-1-Route 1	146	0.59	Address 146
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Start Depot-1-Route 1	152	0.05	Address 152
Start Depot-1-Route 1	153	0.14	Address 153
Start Depot-1-Route 1	154	0.12	Address 154
Start Depot-1-Route 1	155	0.17	Address 155
Start Depot-1-Route 1	156	0.09	Address 156

Source: Authors' own through ArcGIS

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

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Estimation of Land Surface Temperature (LST) and Soil Moisture Index (SMI) using Satellite Image: A Case Study in Bharatpur Municipality, Chitwan, Nepal

By Ramji Kshetri & Dipesh Dahal

Abstract- Monitoring and predicting variations in land surface temperature (LST) and soil moisture index (SMI) using remote sensing technology and modeling methodologies has become essential for making knowledgeable choices regarding crop production, surface evaporation calculation, identification of potential groundwater, and sustain able land use practices. LANDSAT data has opened new possibilities for studying land processes through remote sensing. This study aims to estimate LST and SMI in the Bharatpur municipality, Chitwan, Nepal using ArcGIS software and Landsat 8 data. The four bands of Landsat 8 including band 4, band 5, band 10, and band 11 are used. Running various empirical formulas including normalized difference vegetation index, atmosphere radiance, satellite brightness temperature, land surface emissivity and using the Landsat bands within ArcGIS, processing on the geographic coordinate system (World Geodetic System 1984) and the projected coordinate system UTM (Universal Transverse Mercator) zone 45 N, facilitates the estimation of both land surface temperature and soil moisture index.

Keywords: landsat 8, ArcGIS, normalized difference vegetation index (NDVI), top of atmosphere radiance (L_λ), satellite brightness temperature (BT), land surface emissivity (e).

GJHSS-B Classification: LCC: QC929.L36

ESTIMATIONOFLANDSURFACETEMPERATURELSTANDSOILMOISTUREINDEXSMIUSINGSATELLITEIMAGEACASESTUDYINBHARATPURMUNICIPALITYCHITWANNEPAL

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Estimation of Land Surface Temperature (LST) and Soil Moisture Index (SMI) using Satellite Image: A Case Study in Bharatpur Municipality, Chitwan, Nepal

Ramji Kshetri [α] & Dipesh Dahal [σ]

Abstract- Monitoring and predicting variations in land surface temperature (LST) and soil moisture index (SMI) using remote sensing technology and modeling methodologies has become essential for making knowledgeable choices regarding crop production, surface evaporation calculation, identification of potential groundwater, and sustain able land use practices. LANDSAT data has opened new possibilities for studying land processes through remote sensing. This study aims to estimate LST and SMI in the Bharatpur municipality, Chitwan, Nepal using ArcGIS software and Landsat 8 data. The four bands of Landsat 8 including band 4, band 5, band 10, and band 11 are used. Running various empirical formulas including normalized difference vegetation index, atmosphere radiance, satellite brightness temperature, land surface emissivity and using the Landsat bands within ArcGIS, processing on the geographic coordinate system (World Geodetic System 1984) and the projected coordinate system UTM (Universal Transverse Mercator) zone 45 N, facilitates the estimation of both land surface temperature and soil moisture index. This research concentrates on the ArcGIS raster function and raster calculation using Landsat 8 imagery with a 30-meter resolution captured in October 2021. The observation shows the variation in land surface temperature ranging from 20.6 ˚C to 33.7°C˚C, while the variation in soil moisture index ranged from null to 100%. The land surface temperature has a direct impact on land surface evaporation, soil moisture, and crop yield. Elevated land surface temperatures typically lead to higher rates of surface evaporation, resulting in reduced soil moisture levels and fertility. Consequently, this can potentially lead to a decline in crop production, the extent of which varies depending on the type of crop. Moreover, a decrease in soil moisture levels can hamper groundwater recharge due to limited water availability, further worsening crop productivity and possibly leading to agricultural and hydrological drought. However, to some extent, it increases the soil moisture, especially in the hilly areas, where it helps to melt the snow. furthermore, LST and SMI play a vital role in town and city planning because these factors are responsible for surface water & groundwater availability, crop production, and regulating local and regional climate patterns through their influence on evaporation and transpiration. The findings of this study reveal that remote sensing combined with GIS methodology utilizing Landsat 8 imagery and various empirical formulas can effectively assess the variation of land surface temperature (LST) and soil moisture index (SMI) with high accuracy and also helps to reduce time, costs, and labor associated with environment assessment.

Keywords: landsat 8, ArcGIS, normalized difference vegetation index (NDVI), top of atmosphere radiance (L_λ), satellite brightness temperature (BT), land surface emissivity (e).

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I. Introduction

Land surface temperature is the recorded radiative skin temperature of the land surface measured in the direction of the remote sensor. It refers to how hot the surface of a specific location is, where radiative skin temperature is the temperature of the Earth's surface as measured by its emitted thermal radiation. It is computed by using the top-of-atmospheric brightness temperature from the infrared spectral channels of a constellation of geostationary satellites where the top-of-atmospheric brightness temperature indicates the temperature of the Earth's surface as observed from space without any atmospheric interference. Advan & Jovanovska (2016)identified that LST is a critical factor in many studies, including global climate change, hydrological and agricultural processes, and urban land use & land cover, while Anandababu et al. (2018) state that LST is the key factor for calculating the highest and lowest temperature of a particular location. Land surface temperature affects the rate of evaporation from the soil. High LST increases surface evaporation, which directly affects the soil moisture condition and may lead to drought in a particular area. The Soil Moisture Index (SMI) measures the moisture content of the soil at various depths, which is prominently influenced by precipitation through infiltration. It is a highly changeable variable that varies on a small scale depending on soil properties and drainage patterns. Entezari et al., (2019) insist the soil moisture index plays an essential role in managing water and soil resources. It is measured in index value, which ranges from 0 to 1, with 0 indicating extreme dry conditions and 1 indicating extreme wet conditions.

The land surface temperature and soil moisture index can be regularly estimated for a large region using remote sensing and GIS techniques. In this case study, the estimation of land surface temperature and soil moisture index focuses on near-surface soil moisture, which is typically the top 5 centimeters or less of the topsoil profile. Tajudin et al. (2021) argue that in recent years, remote sensing and GIS have emerged as advanced and more effective tools for monitoring soil moisture index and land surface temperatures. In this study, land surface temperature and soil moisture index

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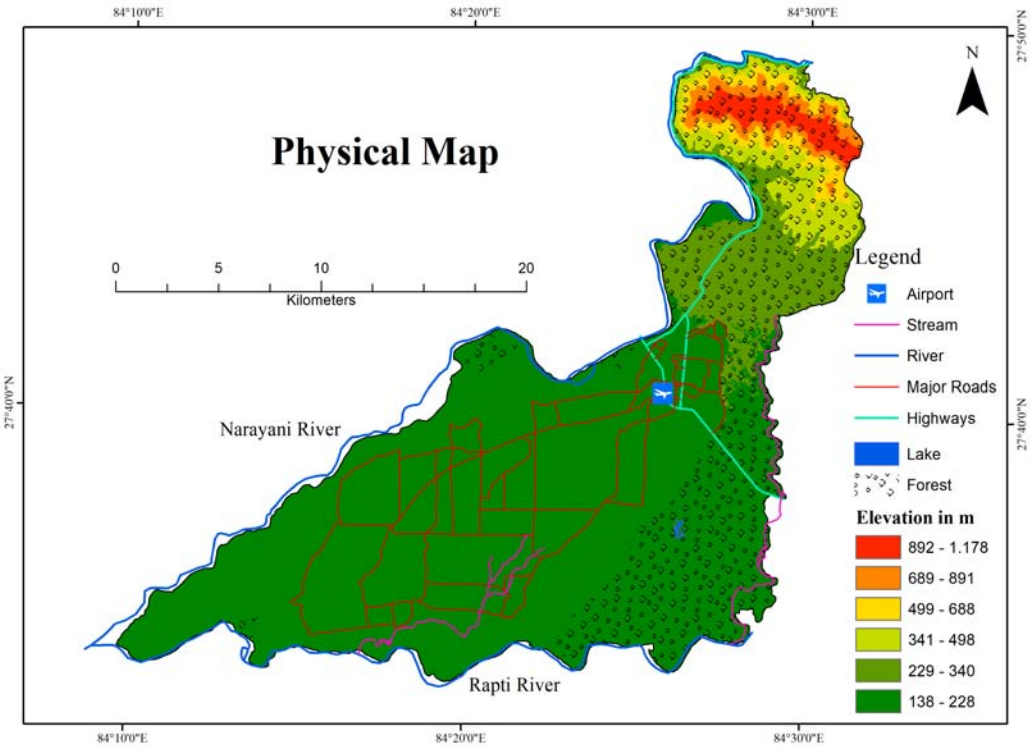
are estimated using thermal emission, vegetation cover, and reflected radiation. Thermal emission is the energy released by any object in the form of electromagnetic radiation due to its temperature, vegetation cover reduces the land surface temperature, and reflected radiation from the surface are the factors that directly affect the rate of the temperature of the earth's surface.

II. Study Area

Bharatpur municipality is part of Chitwan Dune Valley nestled between the range of Mahabharat and Siwalik, at the foothills of the Himalayas (Malla and Karki 2016), which is located in the mid-southern part of Nepal. It experiences a tropical to subtropical climate, with a variety of weather seasons in a year. The average temperature in the area is reported to be 25 ˚C, with annual rainfall ranging from 2000 to 2500 mm (Luitel et al., 2020). Approximately, 80% of the total annual rainfall occurs during the monsoon months between June and September (Pant et al., 2021). The municipality is about 146 km from the capital, Kathmandu, with an area of 433 km^2, with an elevation of 138m – 1178m above sea level. According to the National Census 2021, the population of this area is 369,377.

Figure 1 shows the map of Bharatpur municipality with physical features consists rivers, classified elevation, road networks, and forests. The municipality is bounded by two rivers, Narayani from the west and Rapti from the south. The topography of the southern part is plain and consists of fertile land, while the northern part exhibits varying elevations, ranging from small to high hills. Land cover analysis reveals that the mid southwestern area predominantly comprises agricultural land and settlements, whereas forests dominate the northern to southeastern regions. Bharatpur is also known as the medical city of Nepal and has emerged as a key commercial center for the Chitwan district and the central region of Nepal. Owing to abundant opportunities and facilities, the population of the municipality has witnessed notable growth in recent years.

Figure 2 exhibits the obvious map of types of land use & cover, which is created by using the same Landsat 8 images in the ArcGIS processed through the WGS 1984 geographic coordinated system and UTM zone 45 N projected coordinated system. The land use & land cover map demonstrates significant agricultural land occupying the southwestern region, while forests dominate the southeastern to northern areas. The mid-western section consists of urban or developed areas, with water bodies scattered throughout, including two rivers in the west and south, as well as small lakes and ponds within the municipality.



Source: Ministry of Federal Affairs and General Administration, Government of Nepal.

Figure 1: Study area map

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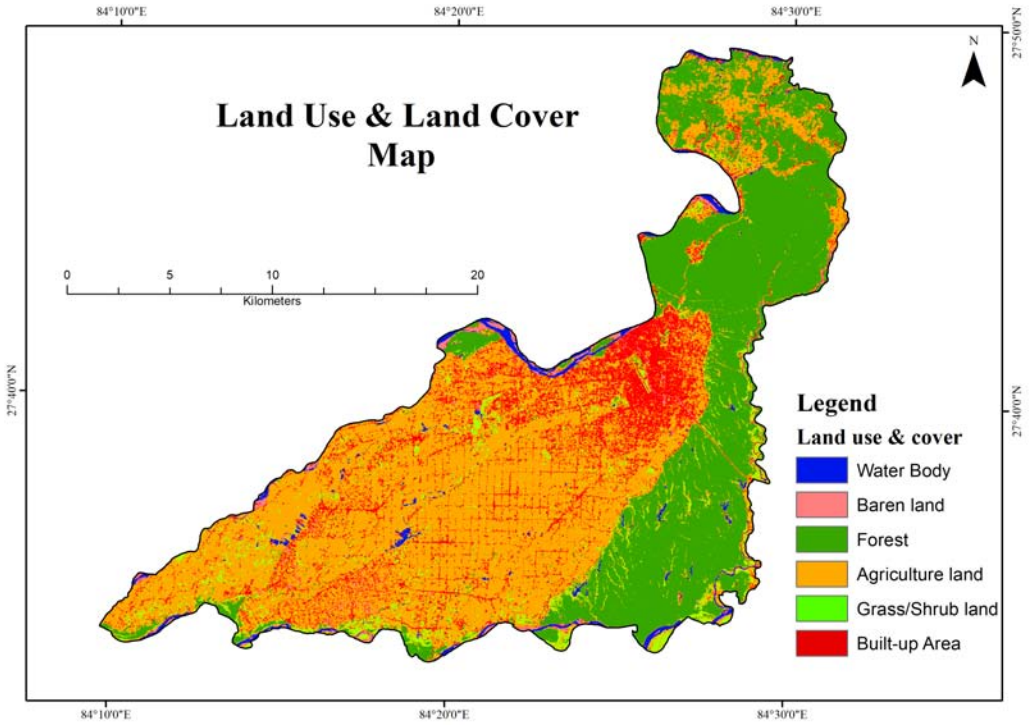

Figure 2: Land use & Land Cover Map of the Bharatpur Municipality.

III. Material and Methods

a) Data Used

The Landsat 8 OLI/TIRS C1 level-1 image with a 30-meter resolution was obtained from the official website of the United States Geological Survey (earthexplorer.usgs.gov), with an acquisition date recorded in October 2021. The downloaded image is used to create the LST and SMI maps with the help of some empirical formulas. Landsat image is processed through ArcGIS software under the worldwide accepted geo-referenced system, World Geodetic System (WGS 1984) and Projected Coordinate System, Universal Transverse Mercator (UTM) 45 N by using four bands of Landsat 8 images level 1(band4, band5, band 10, and band11), and different empirical formulas shown below. The value of LST and SMI must be different in the other seasons because the study area has various climates and temperatures throughout the year. However, it can be useful to represent the land surface temperature and soil moisture index of a particular place at a specific time.

b) Software Used

- ArcGIS 10.8
- LaTeX

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c) *Flow Chart*

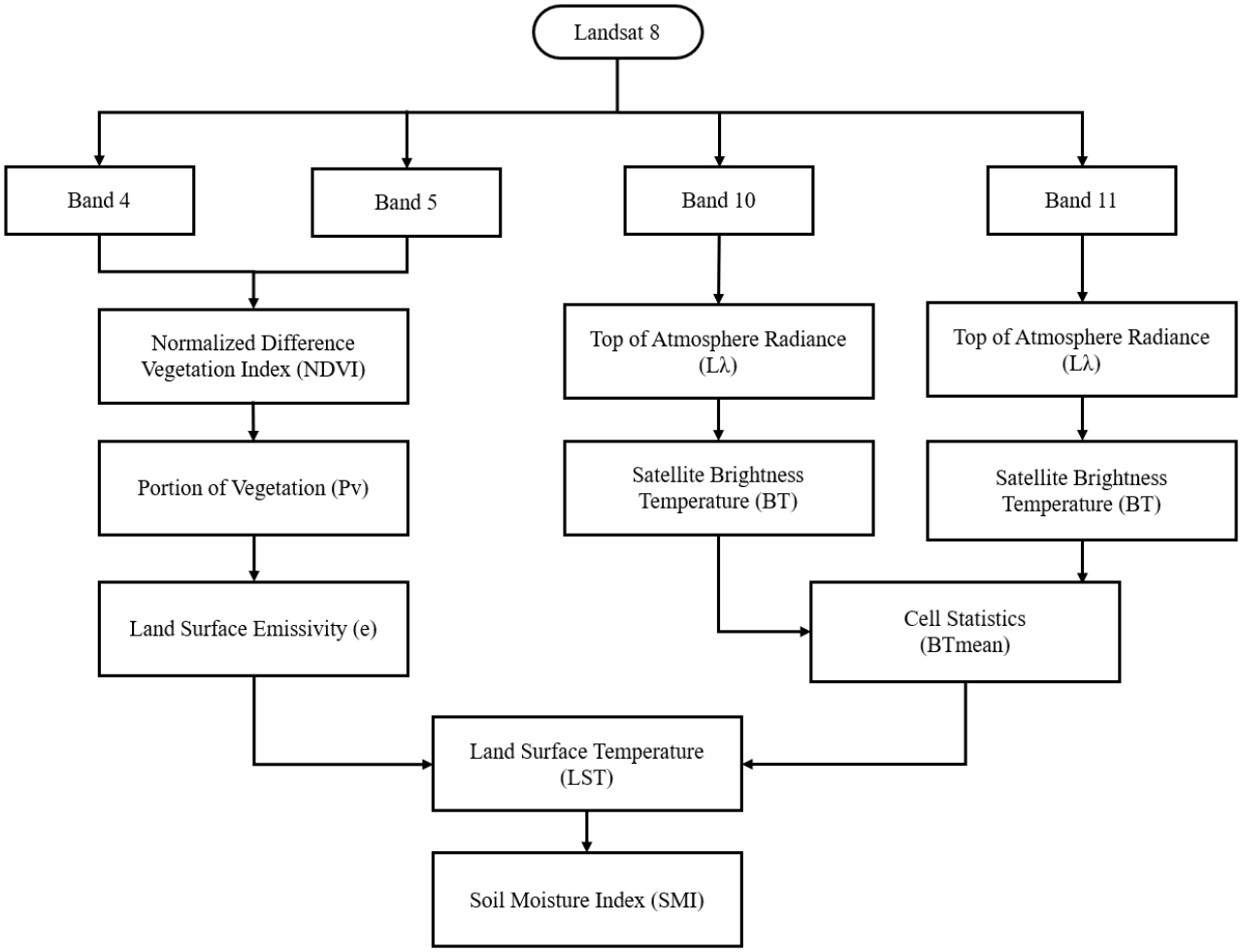

Figure 3: Flow Chart of Land Surface Temperature and Soil Moisture Index Evaluation.

d) *Calculation Process*

i. *Normalized Difference Vegetation Index (NDVI)* The Normalized Difference Vegetation Index (NDVI) serves as an indicator to assess the extent of vegetation coverage within the study area. The index gives a value between -1 and 1 indicating the density of vegetation cover. Entezari et al., (2019) state that NDVI value 1 indicates extensive vegetation, a value close to 0 represents sparse or non-vegetated areas, whereas anything less than zero denotes water and clouds.

NDVI = (NIR – Red) / (NIR + Red) [Anandababu et al. (2018), Sahana et al. (2016), Entezari et al. (2019)] NIR (band5) = DN values from Near Infrared Band

Red (band4) = DN values from Red Band
NDVI = (band5 – band4) / (band5 + band4)

ii. *Top of Atmosphere Radiance (L_λ)*

Remote sensing tools directly measure radiance. Radiance includes radiation reflected from the surface, as well as radiation bouncing in from nearby pixels and radiation reflected from clouds. Top of atmosphere radiance is calculated by using thermal bands, which are band 10 and band 11 respectively. The formula for top-of atmosphere radiance is obtained from (Mission, L., n.d)

$L_\lambda = M_L * Q_{cal} + A_L$ [Anandababu et al. (2018), USGS (Mission, L., n.d)]

where,

L_λ = TOA Spectral Radiance ($Watts/(m^2 * srad * \mu m)$)

M_L = Radiance Multiplicative Band (No.)

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For band 10 = 3.3420E-04 = 0.0003342 (value taken from Metadata file)
For band 11 = 3.3420E-04 = 0.0003342 (value taken from Metadata file)

$Q_{(}cal)$ = Quantized and Calibrated Standard Product pixel value (DN)
A_L = Radiance Add Band (No.)

For band 10 = 0.00001 (value taken from Metadata file)
For band 11 = 0.00001 (value taken from Metadata file)

iii. Satellite Brightness Temperature (BT)

Satellite Brightness Temperature (BT) is calculated by using thermal bands, which are band 10 and band 11 respectively.

BT = $K_2/ln((k_1/L_\lambda) + 1) - 272.15$ [Avdan and Jovanovska (2016), Tajudin et al. (2021)] (converting kelvin to degree Celsius)
where,
BT = Top of atmosphere brightness temperature in degrees Celsius

L_λ = *T OA Spectral Radiance* ($Watts/(m^2 * srad * \mu m)$)

K_1 = Constant band (N0.)
K_2 = Constant band (N0.)
For Landsat 8,

Band 10, K_1 = 774.89 & K_2 = 1321.08 (value taken from metadata file)
Band 11, K_1 = 480.89 & K_2 = 1201.14 (value taken from metadata file)

iv. *Cell statistics*

Calculate the mean brightness temperature for the study area by using the brightness temperature of both bands 10 and 11.

v. *Portion of Vegetation (Pv)*

Pv = ((NDVI - NDVImin) / (NDVImax - NDVImin))^2[Anandababu et al. (2018), Tajudin et al. (2021)] NDVI = DN values from NDVI images
NDVImax = Maximum DN values from NDVI images
NDVImin = Minimum DN values from NDVI images

vi. *Land Surface Emissivity (LSE)*

It is an average emissivity of an element of the earth's surface, calculated from NDVI values. e = 0.004* Pv + 0.986 (correction value for Landsat image, Cv) [Anandababu et al. (2018), Tajudin et al. (2021)]

vii. *Land Surface Temperature (e)*

$LST = BTmean/(1 + (\lambda * BTmean/\rho) * ln(e))$ [Entezari et al. (2019), Rajendran and Mani (2015)] λ = Wavelength of emitted radiance = 10.895 μmk

$\rho = h * c/\sigma = 1.4388 * 10^2 M\, k = 14388 \mu k$

σ = Boltzmann constant ($1.38 * 10^{-23} J/K$)

h = Planck's constant ($6.626 * 10^{-34} Js$)

c = Velocity of light ($2.998 * 10^8 m/s$)

viii. *Soil Moisture Index (SMI)*

SMI = (LSTmax - LST) / (LSTmax - LSTmin) [Tajudin et al. (2021)]
LSTmax = Maximum surface temperature for given NDVI
LSTmin = Minimum surface temperature for given NDVI

To begin with the land surface temperature and soil moisture index assessment in the Bharatpur municipality, the Landsat 8 image was obtained from the official website of the United States Geological Survey, earthex plorer.usgs.gov. The file consists of 11 bands of Landsat and metadata file in mtl format. Among them, we need only band 4, band 5, and thermal bands 10 & 11 for GIS processing and some values from the metadata file. GIS processing includes various mathematical computations performed using the raster calculator tool. This tool is typically located within an Arc toolbox, under Spatial Analyst tools, within the Map Algebra section.

Normalized Difference Vegetation Index (NDVI) is calculated by using band 4 and band 5 from the Landsat image. Band 4 corresponds red light spectrum (visible red) also called the red band, which is absorbed by chlorophyll in vegetation. On the other hand, band 5 corresponds to near-infrared light (NIR), which is reflected by vegetation. The vegetation cover is calculated by using the empirical formula given above (Section 3.4, i).

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Top of Atmosphere Radiance (L_λ) and Satellite Brightness Temperature (BT) are calculated for both thermal bands 10 and 11 respectively. The values of M_L, A_L, K_1, *and* K_2 are taken from the metadata file to identify both (L_λ) and BT, where $Q_{(}cal$) is the standard product pixel value of both bands 10 and 11 respectively. As shown in the flow chart, a mean value of brightness temperature is calculated from both bands. Mean brightness temperature is used to calculate the Land Surface Temperature (LST) for more accuracy.

Both Portion of Vegetation (Pv) and Land Surface Emissivity (e) are calculated correspondingly from NDVI values. Both land surface emissivity (e) and mean brightness temperature (BTmean) with other standard values such as the wavelength of emitted radiance, Boltzmann constant, Planck's constant, and velocity of light are used to identify land surface temperature. The empirical formulas for Land Surface Temperature and Soil Moisture Index are previously stated in the calculation process section.

After applying the given formulas and processing the Landsat 8 image through GIS software using the raster calculator tool, the study area's final maps depicting land surface temperature and soil moisture index were generated. These maps were then presented, analyzed, and discussed in detail in the results section.

IV. Results

a) *Normalized Difference Vegetation Index (NDVI)*

The Normalized Difference Vegetation Index (NDVI) serves as an indicator of vegetation presence. Landsat image bands 4 and 5 are employed to calculate this index. The result shows the presence of water bodies, null vegetation, and partially dense vegetation in the study area. Figure 4 shows the vegetation cover in the study area where a large part is dominated by a green color indicating dense vegetation including forests, cultivated fields, and nurseries. Notably, this dense vegetation is particularly prominent in the eastern region and has 74% of the total area. The yellow-shaded area indicates the area has partial to negligible vegetation cover, which consists of 23% of the total study area and typically represents bare land and urban area as referenced in Figure 2. Additionally, the red spot area typically lacks vegetation, indicating water bodies including rivers and lakes, accounting for 3% of the total area as referenced in Figure 2.

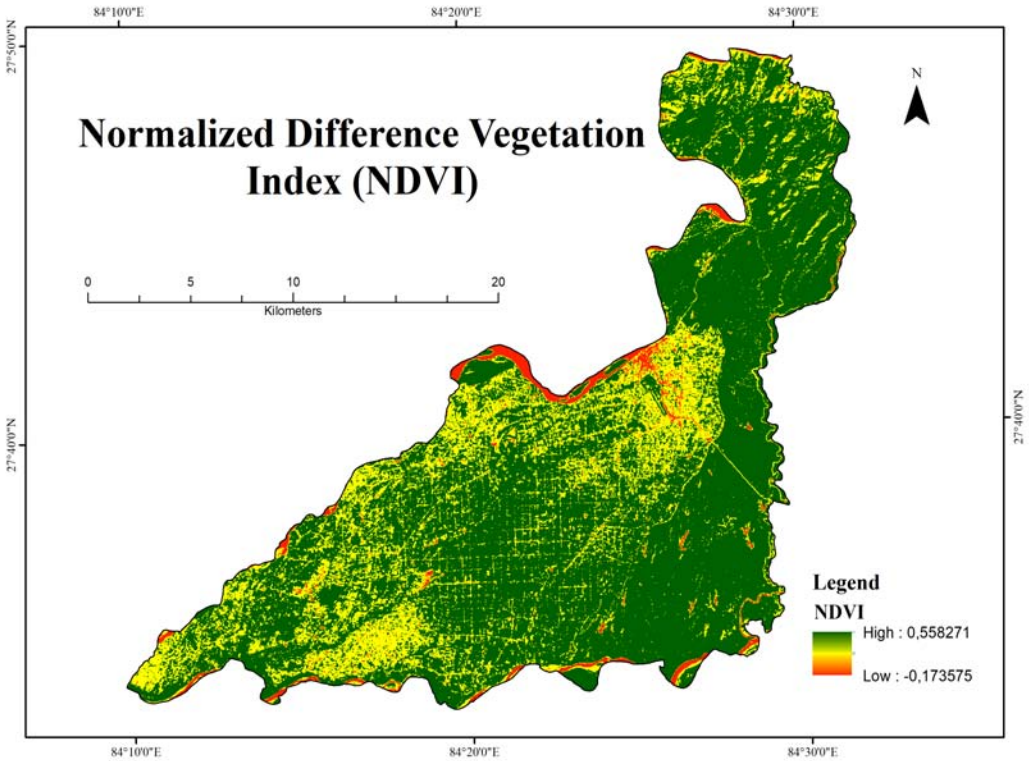

Figure 4: Normalized Difference Vegetation Index (NDVI) Map for October 2021.

b) *Land Surface Temperature (LST)*

The land surface temperature and soil moisture index range has been determined in the study area following GIS analysis. Figure 5 illustrates the land surface temperature variation in the Bharatpur municipality in October 2021. High land surface temperatures were observed in densely inhabited lowland areas, while low surface temperatures were found in high-altitude areas in the north and underwater regions as referenced in Figure 1 and Figure 2 respectively. The map of the land surface temperature groupings is presented in Table 1 for a better

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understanding of the places, which could be useful for the selection of crops for farming, fish farming, and land use planning. The larger part of the area has temperatures between 25˚C and 28˚C, constituting approximately 56%, followed by temperatures between 23˚C and 25˚C, accounting for about 32%. To overview the above results, it can be concluded that the study area exhibits an average temperature of land is approximately 25˚C.

Table 1: Land Surface Temperature Classes with Area in Square Kilometers.

S.No.	LST Classes in ˚C	Area (km^2)	Area (%)
1	30.00 – 33.71	0.92	0.21
2	28.00 – 30.00	33.28	7.67
3	25.00 – 28.00	240.38	55.38
4	23.00 – 25.00	137.84	31.76
5	20.67 – 23.00	21.56	4.98

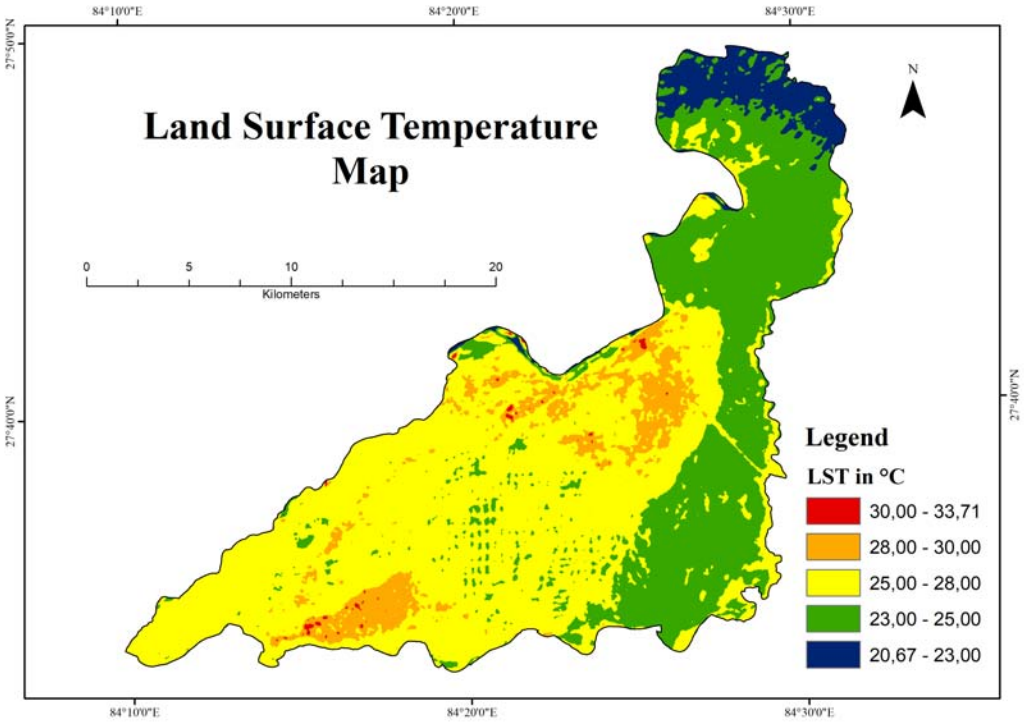

Figure 5: Land Surface Temperature Map of Bharatpur Municipality.

c) Soil Moisture Index (SMI)

The soil moisture index map shown in Figure 6 demonstrates that areas with higher altitudes and water bodies surrounded by forests have greater soil moisture levels as referenced in Figure 1 and Figure 2 respectively. Additionally, regions with dense forest cover on low-lying terrain have good moisture conditions aligning with observations from Figures 1 and 2 respectively. Conversely, low-lying regions characterized by built-up areas have a lower moisture content as referenced in Figure 2. In total, more than 50% of an area has more than 50% moisture content in the soil, which depicts a large part of an area has a wet condition and a few areas have a dry to slightly moist condition. However, the analysis was done just before winter and after the monsoon season (October). So, there will be a high chance of decreasing moisture content in the spring and summer seasons. The range of soil moisture index from very low to very high and their area are shown in Table 2, respectively. The result shows that

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most of the area has an SMI value of 40% to 80%. The division of soil moisture index 0% to 100% is useful for land use practice because it plays a crucial role in supporting plant growth, maintaining the fertility of the soil by providing water for irrigation, and groundwater recharge.

Table 2: Soil Moisture Index Classes with Area in Square Kilometers.

S.No.	SMI Classes in Range	Area (km^2)	Area (%)
1	0.8 – 1.0	25.05	5.77
2	0.6 – 0.8	255.25	58.82
3	0.4 – 0.6	136.1	31.36
4	0.2 – 0.4	17.47	4.02
5	0.0 – 0.2	0.11	0.03

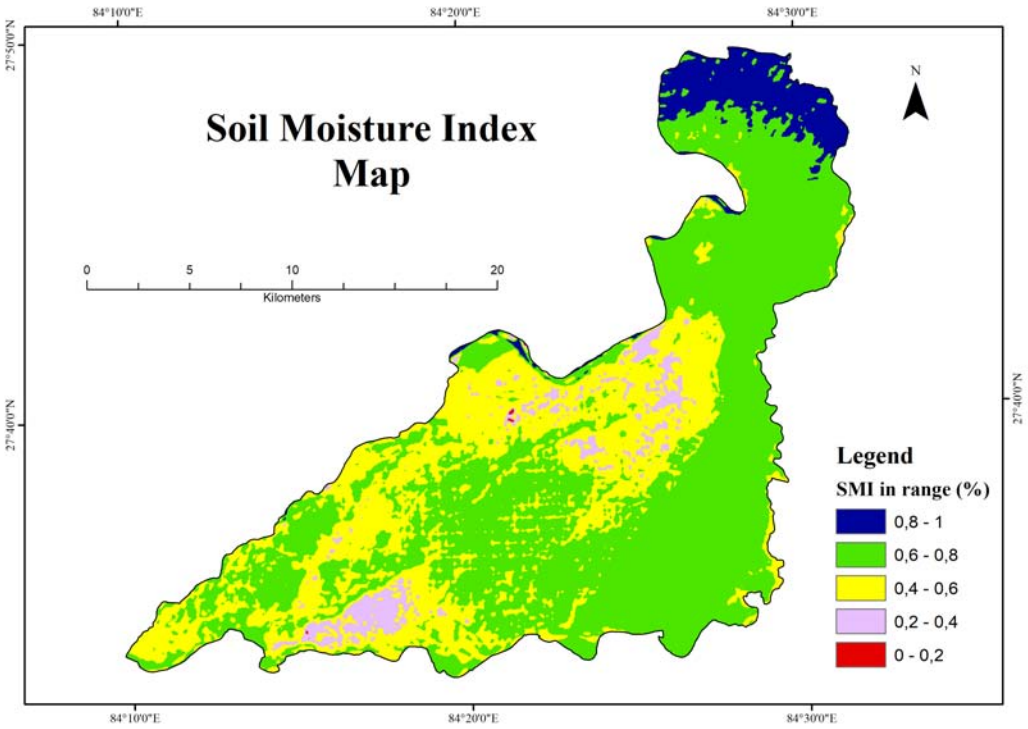

Figure 6: Soil Moisture Index Map of Bharatpur Municipality.

V. Conclusion

The estimation of land surface temperature and soil moisture index using remote sensing and GIS techniques has successfully identified the variation of these two climatic factors over the study area. The result shows variations in the land surface temperature across the municipality from 20.6°C to 34.7°C. At the same time, the soil moisture index indicates some parts of the study area are waterlogged and some areas have water drought. The results indicate the inverse relation between land surface temperature and soil moisture index, where a higher land surface temperature area has a low soil moisture index and low land surface temperature has a high soil moisture index. However, the relation between these could be reversed in different locations, particularly in high altitude areas, where high land surface temperature facilitates the snow melt, leading to increased soil moisture despite the high temperature. The obvious picture of these two environmental facilitates environmental monitoring including heat distribution and moisture conditions over the study area and integrating them enables a drought monitoring system by identifying locations with high temperatures and low soil moisture levels. In addition, a combined analysis of these two environmental factors

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helps to identify the heat-prone, water scarcity, and waterlogged areas, which enables a guide to make decisions regarding town planning, agriculture planning, crop selection, and irrigation scheduling across the area.

The outcome results derived from this technique demonstrated that this model can estimate the variation of both land surface temperature and soil moisture in the shortest time and with acceptable accuracy over a large geographical area. Landsat 8 OLI/TIRS C1 level 1 is used to determine the thermal and environmental characteristics of the land surface environment. The distribution of Land Surface Temperature (LST) and Soil Moisture Index (SMI) across the study area was determined through a comprehensive process including normalized difference vegetation index, satellite brightness temperature, the portion of vegetation, and land surface emissivity. The findings of this investigation illustrate how the technique achieves a higher degree of precision when evaluating land surface characteristics.

In a nutshell, this study demonstrates the effectiveness of remote sensing and geographic information system tools in understanding ground surface environmental dynamics. These modern methods not only allow for greater depth of knowledge, but also significantly reduce the time, cost, and manpower for environmental assessments.

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Author Contribution: The authors have the original idea for the paper and took overall responsibility for the study, including data collection and analysis, preparation of figures, and finalization of the manuscript.

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Co_2: A Contemporary Analysis of the Impact of Economic Growth and Energy on Carbon Dioxide Emissions

By Marco Aurélio Vieira, Paulo Sergio Ceretta & João Pedro Velho

Abstract- In today's world, there is a growing concern about environmental preservation and the impact of human actions on it. The Brazilian Panel on Climate Change highlights the interference of these actions, which reach a global scale and unprecedented magnitude. The intensification of carbon dioxide (CO2) emissions into the atmosphere since the Industrial Revolution has been a significant factor in global climate change and the intensification of the greenhouse effect. Therefore, the objective of this thesis is to investigate the impact of energy consumption and economic growth on carbon dioxide emissions. This thesis is classified as explanatory research and is characterized by a quantitative approach. The final sample consisted of 69 countries, observed for a period of 11 years; the data were collected from the World Bank database. The analysis was carried out using the dynamic panel data structural model with fixed effects, estimated by Maximum Likelihood. The research concludes that: i) for a 1% increase in countries' income, there was an 0.18% increase in CO2 emissions; ii) a 1% increase in renewable energy consumption had the positive effect of reducing emission levels by 0.12%; iii) however, the increase in non-renewable energy consumption aggravated the carbon dioxide problem by 0.2%; iv) a 1% increase in the total population caused a 0.21% increase in CO2 emissions; v) for a 1% increase in countries' credit, there was a 0.13% increase in CO2 emissions.

Keywords: *carbon dioxide emissions. economic growth. climate change. energy. environment.*

GJHSS-B Classification: *LCC Code: QC879.8*



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Co_2: A Contemporary Analysis of the Impact of Economic Growth and Energy on Carbon Dioxide Emissions

Marco Aurélio Vieira [α], Paulo Sergio Ceretta [σ] & João Pedro Velho [ρ]

Abstract- In today's world, there is a growing concern about environmental preservation and the impact of human actions on it. The Brazilian Panel on Climate Change highlights the interference of these actions, which reach a global scale and unprecedented magnitude. The intensification of carbon dioxide (CO2) emissions into the atmosphere since the Industrial Revolution has been a significant factor in global climate change and the intensification of the greenhouse effect. Therefore, the objective of this thesis is to investigate the impact of energy consumption and economic growth on carbon dioxide emissions. This thesis is classified as explanatory research and is characterized by a quantitative approach. The final sample consisted of 69 countries, observed for a period of 11 years; the data were collected from the World Bank database. The analysis was carried out using the dynamic panel data structural model with fixed effects, estimated by Maximum Likelihood. The research concludes that: i) for a 1% increase in countries' income, there was an 0.18% increase in CO2 emissions; ii) a 1% increase in renewable energy consumption had the positive effect of reducing emission levels by 0.12%; iii) however, the increase in non-renewable energy consumption aggravated the carbon dioxide problem by 0.2%; iv) a 1% increase in the total population caused a 0.21% increase in CO2 emissions; v) for a 1% increase in countries' credit, there was a 0.13% increase in CO2 emissions. It is proposed that everyone adopt measures related to alternative energy technologies. In addition, it is recommended to invest in education, encourage behavior change, and raise public awareness about the impact of CO2 emissions. This work has some limitations, such as the time restriction and the lack of complete and accurate data, which resulted in the exclusion of some countries from the analysis. Regarding future perspectives, it is suggested to explore additional variables to understand the factors that influence CO2 emissions.

Keywords: carbon dioxide emissions. economic growth. climate change. energy. environment.

I. Introduction

The concept of the global energy matrix has evolved from the extraction of fossil fuels, deposited in natural reserves over millions of years. Since the advent of the Industrial Revolution in the mid-18th century, a period marked by technological development, CO2 emissions into the atmosphere have intensified.

Issues related to Earth's climate and the challenges affecting the environment have been increasingly addressed in recent decades. In this context, the Brazilian Panel on Climate Change highlights the interference of human actions on the environment and how this affects the natural functioning of the climate system. According to Cortese and Natalini (2014), due to the unprecedented global scale and magnitude of climate change, the term has become widely used in everyday communication by both the media and the scientific community.

For Marcovitch (2007), climate change is relegated to a secondary position on the global agenda, given the priority placed on war and economic issues, as observed at leadership conferences at the United Nations (UN). However, "with its global repercussions, climate change demands three simultaneous readings of different times and values" (MARCOVITCH, 2007, p. 24).

From the contemporary post-industrial perspective of Abramovay (2012), the Green Economy is an approach to economic development that aims to reconcile economic growth with environmental protection and natural resource conservation. It seeks to integrate environmental issues into economic policies, striving for more sustainable economic growth that promotes economic prosperity, social equity, and environmental protection.

Abramovay's (2012) green economy proposes a new form of economic development, based on cleaner, more efficient, and renewable practices and technologies, aiming to stimulate innovation, the creation of green jobs, and the reduction of greenhouse gas emissions and other negative impacts on the environment.

In summary, based on the outlined questions, this research seeks to answer the following research problem: considering the above, what is the impact on CO2 emissions generated through energy consumption and economic growth?

The objective of this research is to estimate the impact of economic growth and energy on carbon dioxide emissions. This thesis adds to the challenge of understanding the results or resolving doubts regarding contemporary studies on the environment, especially considering CO2 emissions as the main element. In practical terms, it is believed that bringing forth calculations and conclusions that support, or not,

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publications from the scientific community can contribute to a deeper understanding of the topic.

II. Theoretical Framework

The Paris Agreement, adopted on December 12, 2015, by the Parties to the United Nations Framework Convention on Climate Change, aimed primarily at reducing greenhouse gas emissions from 2020 onwards. The negotiation is considered a significant challenge among nations regarding the risks and impacts of global climate change, as well as in obtaining resources to implement the Agreement.

In addition, the main goals are highlighted: To increase the capacity to adapt to the adverse impacts of climate change; to promote climate resilience and low greenhouse gas emission development in a manner that does not threaten food production; and to make financial flows consistent with a pathway to low greenhouse gas emissions (UNFCCC, 2015).

According to Mitchell et al. (2018), the Paris Agreement established targets signed by participating countries consensually. They were intentions of more ambitious long-term temperature reduction, implying greater rigor in emissions reduction. Article 2 of the Paris Agreement identifies its main objectives, such as keeping the increase in global average temperature below 2°C compared to pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change.

Rajamani and Werksman (2018), in analyzing the legal nature of the target contained within the overall framework of the Paris Agreement, in which nearly 200 sovereign nations reached a consensus, all countries agreed on the challenge of keeping the global temperature increase below 2°C in the long term. The impacts of not achieving the target are predicted, as emissions trends, greenhouse gas concentrations in the atmosphere, and the increase in global average temperature could lead to irreversible effects for humanity, emphasize the authors, along with the need for individual and collective awareness.

According to Rajamani and Werksman (2018), concerns about the viability of the agreement are inevitable, as there is no specific legally binding provision regarding the actions of each of the Parties after the agreement. Nevertheless, it implies that commitment and adaptation costs are likely to increase; however, there is a lack of provisions regarding applicable financing related to the operational role, both at the national and international levels, especially in the existential aspirations of the most vulnerable countries.

As per Millar and Friedlingstein (2018), fossil fuels provide energy for most of our fundamental technologies, presenting a challenge to achieving the goals of the Paris Agreement. In the current historical record of the agreement, we are at the threshold of future cumulative CO2 emissions; concerning the value presented, there are chances, at best, to limit warming to 1.5°C.

Millar and Friedlingstein (2018) state that overcoming this challenge is inevitable for the strategic need for vigorous or preventive responses that eliminate the possibility of further climate change. Even when assuming a very strong demand for energy consumption, initiatives to reduce fossil fuel emissions are still not ruled out. However, an essential step in stabilizing the climate, in any situation, is the balance of anthropogenic sources and sinks, so that the reduction of net carbon dioxide emissions to zero is successful. However, based on the available evidence in the UNFCCC process (2015), it is noted that the term anthropogenic applies to both emissions from sources and removals by sinks.

When considering institutional theory as one of the objects of analysis in this work, it is necessary to first seek the context in which it is inserted, and a greater understanding of concepts studied by other authors. In this sense, Scott (2008) asserts that institutional theory is an economic theory that studies social institutions and the forms of regulation that influence economic decision-making and the behavior of individuals. It focuses on how institutions, including laws, regulations, and social norms, affect economic development and the relationships between different economic actors.

According to DiMaggio and Powell (1983), ¡nstitutional theory is used to understand changes in the structural arrangements of organizations because it focuses on the norms and values that guide how organizations are structured and operate. The theory highlights that social institutions, including organizations, are influenced by a set of normative pressures, including external regulations and internal practices. Changes in normative pressures can lead to changes in the structure and practices of organizations. Thus, the use of institutional theory helps to understand how these changes arise and how organizations adapt to them over time.

According to Tolbert and Zucker (1999), in institutional theory, organizations are influenced by normative pressures because these norms provide a way to establish expectations and behavioral standards for organizational actions. External normative pressures, such as those from the state, are shaped by legal regulations and public policies that organizations must adhere to. Internal normative pressures result from traditions, values, and practices established within the organization over time. Both sources of normative pressures help to define social expectations and ensure that organizations act appropriately and responsibly.

For DiMaggio and Powell (1983), institutional theory results from the convergence of influences from different theoretical bodies, such as political science, sociology, and economics, because these disciplines

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recognize the importance of institutions and patterns of behavior, norms, values, beliefs, and assumptions in understanding human and organizational conduct. Institutional theory seeks to integrate these influences to provide a more comprehensive view of how social institutions, including organizations, are formed and influenced by these behavioral patterns, values, and beliefs.

According to Meyer and Rowan (1977), in institutional theory, organizations are compelled to incorporate practices and procedures defined by rationalized concepts of organizational work because these concepts are seen as accepted and socially recognized standards. They provide a common basis for decision-making and for defining roles and responsibilities in organizations. Additionally, external institutions, such as government regulations and sectoral norms, may impose these rationalized concepts and require organizations to incorporate them into their practices and procedures. Adopting these rationalized concepts of organizational work allows organizations to achieve greater efficiency and effectiveness in their operations, which can be advantageous in terms of competitiveness and market survival. Therefore, organizations have incentives to incorporate these rationalized concepts into their practices and procedures.

Powell and Colyvas (2008) argue that institutional theory seeks to explain the structure and functioning of organizations as socially constructed realities because they believe that institutions are not mere formal structures, but are the result of social interactions and historical processes. According to this theory, institutions are shaped by values, beliefs, norms, and collective expectations, and these social characteristics influence how organizations operate and develop. Additionally, institutions also influence individual actions, and this interaction between institutions and individuals helps to explain economic behavior. Overall, institutional theory provides a theoretical basis for explaining how social institutions are structured and how they influence human and organizational behavior.

III. Scientific Method

Regarding its objective, the present thesis is classified as explanatory research and characterized by a quantitative approach, which seeks to identify the factors that contribute to or determine the occurrence of phenomena. "This is the type of research that deepens the understanding of reality because it explains the reasons for the facts" (FIGUEIREDO, 2007, p. 93). A set of data extracted from the World Bank database (WDI, 2022) between 2010 and 2021 was employed, covering a period of 11 years. The final sample consisted of 69 countries, as shown in Table 1.

Table 1: Distribution of Countries in Continental Regions

Region	Countries
Americas	Argentina, Brazil, Canada, Chile, Colombia, Ecuador, United States, Mexico, Peru, and Venezuela.
Asia	Saudi Arabia, Azerbaijan, Bangladesh, Kazakhstan, China, United Arab Emirates, Philippines, Hong Kong SAR, India, Indonesia, Iran, Iraq, Israel, Japan, Kuwait, Malaysia, Oman, Pakistan, Russia, Singapore, Sri Lanka, Thailand, Turkey, and Vietnam
Africa	South Africa, Algeria, Egypt, and Morocco
Europe	Germany, Austria, Azerbaijan, Belarus, Belgium, Bulgaria, Cyprus, Croatia, Denmark, Slovakia, Slovenia, Spain, Estonia, Finland, France, Greece, Hungary, Ireland, Iceland, Italy, Latvia, Lithuania, Luxembourg, North Macedonia, Norway, Netherlands, Poland, Portugal, United Kingdom, Romania, Russia, Sweden, Switzerland, Czech Republic, and Turkey
Oceania	Australia and New Zealand

Source: Author (2022)

Countries with missing data for the entire period were excluded; thus, balanced data were used, representing a total of 759 observations. The variables included in this study are as follows: carbon dioxide emissions "emi_c", carbon dioxide emissions (t-1) "emi_c_1", renewable energy "en_r", non-renewable

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energy "en_nr", GDP per capita "gdp_c"; in addition to control variables: domestic credit to the private sector "cre_c", and total population "pop_c".

Carbon dioxide is a greenhouse gas produced by the burning of fossil fuels such as oil, natural gas, and coal, as well as by the degradation of organic matter such as wood. Carbon dioxide emissions are one of the main factors responsible for current climate change, as an increase in its concentration in the atmosphere contributes to global warming. Most carbon dioxide emissions come from the burning of fossil fuels to produce energy, transportation, heating and cooling of buildings, and other industrial activities. Other sources of carbon dioxide emissions include cement production, fertilizer production, and deforestation.

The variable highlighted as carbon dioxide emissions (t-1) refers to the lagged variable in the previous period. It indicates the relationship of the dependent variable, carbon dioxide emissions, with itself, in the previous year. Renewable energy is generated from natural sources that are renewable and inexhaustible, such as the sun, wind, water, biomass, and heat from the Earth's interior. These energy sources are considered renewable because they can be constantly replenished and do not generate toxic or polluting waste, as is the case with fossil fuels.

Non-renewable energy is energy that is depleted with use, such as fossil fuels (oil, natural gas, and coal). They are formed from organic matter that decomposed millions of years ago and was transformed by the pressure and temperature of the Earth's layers.

GDP per capita is a measure of a country's Gross Domestic Product divided by its population. It is widely used to compare the level of wealth and well-being among countries, as it takes into account the size of the country's population. GDP per capita is usually expressed in terms of international dollars, which allows for direct comparisons between countries with different currencies. Countries with a high GDP per capita tend to have a more developed economy and a population with a higher level of income and well-being. On the other hand, countries with a low GDP per capita tend to have a less developed economy and a population with a lower level of income and well-being.

Internal credit to the private sector is an economic indicator that measures the volume of financing that financial institutions, such as banks and credit companies, provide to private companies to finance their activities. This type of credit is an important source of financing for companies because it allows them to invest in new projects, expand their operations, and hire more employees. Internal credit to the private sector can also be an indicator of investors' confidence in the economy and private companies.

Total population is the number of inhabitants of a country, region, or city. It is an important indicator for assessing the capacity of a place to support the demand for services and infrastructure, as well as for assessing pressure on natural resources and environmental impact. Population can also affect economic growth, as an increase in population can increase the supply of labor and, therefore, economic production.

In this analysis, the dynamic panel data structural model (ANDRADE; TIRYAKI, 2017), with fixed effects, estimated by Maximum Likelihood, was used. Path analyses were conducted in all situations using the system of equations to estimate the direct and indirect effects of the explanatory variables on the dependent variable. The equations relating the dependent and independent variables are as described in the formulas below:

$$emi_c = en_r + en_nr + emi_c_1 + pop_c + gdp_c + cre_c + erro$$

$$en_nr = gdp_c + pop_c + emi_c_1 + erro$$

$$gdp_c = cre_c + pop_c + erro$$

In the regression estimation, a characteristic aspect of structural modeling is observed because, in the model, the variables denoted as emi_c, en_nr, and gdp_c appear as the independent variables. While en_nr and gdp_c appear both as dependent and independent variables. In contrast, emi_c_1, en_r, pop_c, and cre_c form the dependent variables of the model. All analyses were performed using natural logarithm values, through the RStudio software (ROSSEEL, 2012).

IV. Presentation and Analysis of Results

The results of the dynamic panel data structural model with fixed effects are shown in Table 1. All variables were transformed into natural logarithm annual values, for the period from 2010 to 2021, for 69 countries. The estimated standardized coefficients are significant at the 1% level.

The variable carbon dioxide emissions is classified as endogenous, while the variables non-renewable energy and GDP per capita are presented as both endogenous and exogenous simultaneously. Only as exogenous are observed the variables: renewable energy, carbon dioxide emissions in (t-1), total population, and domestic credit to the private sector.

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Table 1: Standardized Coefficients of the Structural Model for the Period from 2010 to 2021

Variables		Coefficients	Z-test	P-value	Confidence Interval	
Endogenous	Exogenous				Lower	Upper
emi_c						
	en_r	-0,124	-5,301	0,000	-0,170	-0,078
	en_nr	0,202	8,725	0,000	0,157	0,248
	emi_c_1	0,528	22,508	0,000	0,482	0,574
	pop_c	0,206	8,972	0,000	0,161	0,251
	gdp_c	0,180	7,840	0,000	0,135	0,225
	cre_c	0,132	5,508	0,000	0,085	0,179
en_nr						
	gdp_c	-0,135	-4,224	0,000	-0,198	-0,073
	pop_c	-0,229	-7,012	0,000	-0,293	-0,165
	emi_c_1	0,341	10,998	0,000	0,281	0,402
gdp_c						
	cre_c	-0,327	-10,842	0,000	-0,386	-0,268
	pop_c	0,124	3,838	0,000	0,061	0,188

Fonte: Resultado da pesquisa (2022)
Nota: emi_c = emissões de CO2, emi_c_1 = emissões de CO2 defasada no ano anterior, en_nr = energia não renovável, gdp_c = PIB, en_r = energia renovável, pop_c = população, cre_c = crédito.

Source: Research Findings (2022)
Note: emi_c = CO2 emissions, emi_c_1 = lagged CO2 emissions, en_nr = non-renewable energy, gdp_c = GDP, en_r = renewable energy, pop_c = population, cre_c = credit.

The estimation of coefficients for the endogenous variable CO2 emissions is as follows: renewable energy indicates a negative coefficient of 0.124, with a confidence interval ranging from 0.078 to 0.170; non-renewable energy indicates a positive coefficient of 0.202, with a confidence interval ranging from 0.157 to 0.248; CO2 emissions in (t-1) indicates a positive coefficient of 0.528, with a confidence interval ranging from 0.482 to 0.574. Total population indicates a positive coefficient of 0.206 with a confidence interval ranging from 0.161 to 0.251; GDP per capita indicates a positive coefficient of 0.180, with a confidence interval ranging from 0.135 to 0.225; domestic credit to the private sector indicates a positive coefficient of 0.206, with a confidence interval ranging from 0.161 to 0.251.

The estimation of coefficients for the endogenous variable non-renewable energy is as follows: GDP per capita indicates a negative coefficient of 0.135, with a confidence interval ranging from 0.073 to 0.198; total population indicates a negative coefficient of 0.229, with a confidence interval ranging from 0.165 to 0.293; CO2 emissions in (t-1) indicates a positive coefficient of 0.341, with a confidence interval ranging from 0.281 to 0.402.

The estimation of coefficients for the endogenous variable GDP per capita is as follows: domestic credit to the private sector indicates a negative coefficient of 0.327, with a confidence interval ranging from 0.268 to 0.386; total population indicates a positive coefficient of 0.124, with a confidence interval ranging from 0.061 to 0.188.

The Structural Model Path Analysis diagram (Figure 1) illustrates the proposed relationships in this thesis. Structured by path analysis, based on the theoretical framework, under the magnitude of direct and indirect effects among the dimensions presented for this stage of the results.

The results demonstrate that renewable energy has a direct and negative impact on CO2 emissions. This means that a 1% increase in renewable energy significantly reduces carbon dioxide emissions by 0.12%. Consistent with previous research, such as the findings estimated by Cao et al. (2022), Belucio et al. (2022), and Samour, Moyo, and Tursoy (2022).

Renewable energy sources do not produce carbon dioxide emissions when used to generate energy because they do not rely on the combustion of fossil fuels. Instead, renewable energy sources utilize natural processes such as sunlight, wind, and water flow to generate energy.

The results for non-renewable energy show a direct and positive impact on CO2 emissions. This means that a 1% increase in non-renewable energy will significantly increase carbon dioxide emissions by 0.2%. Consistent with previous research such as the findings estimated by Sadiq et al. (2022), Rasheed et al. (2022), and Chu and Le (2022).

In this context, institutional theory highlights that institutions, including governments and businesses, play a crucial role in shaping policies and incentives that influence the adoption of renewable energy sources. For example, government policies promoting renewable energy sources such as solar and wind energy, and business practices investing in clean energy sources, contribute to the reduction of CO2 emissions.

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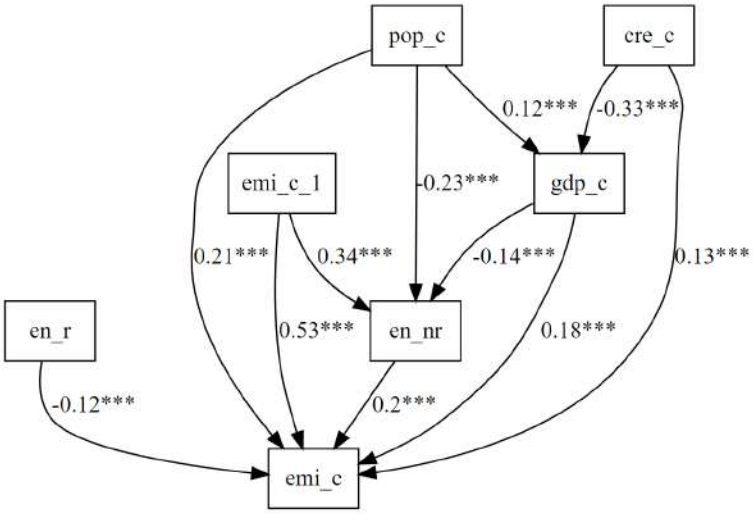

Source: Research Findings (2022)

Figure 1: Structural Graph of the Dynamic Panel Model with Fixed Effects Estimated by Maximum Likelihood.

According to Sadiq et al. (2022), non-renewable energies such as oil, natural gas, and coal are energy sources produced from finite natural resources that, once consumed, cannot be reused. When these fuels are burned to produce energy, they release carbon dioxide into the atmosphere.

Rasheed et al. (2022) state that the increasing use of non-renewable energy is particularly related to countries with a large economy and a developed industrial sector; to countries with a rapidly growing economy and an expanding industrial sector; and to countries with a diversified economy and a developed energy sector but heavily rely on fossil fuels to generate energy.

According to institutional theory, government policies favoring the use of non-renewable energy sources due to their availability and low cost, and the lack of incentives for the adoption of renewable energy sources, contribute to the increase in CO2 emissions.

The results for CO2 emissions (t-1) show a direct and positive impact on CO2 emissions. This means that a 1% increase in CO2 emissions (t-1) will increase carbon dioxide emissions by 0.53%. Consistent with findings in Azevedo, Sartori, and Campos (2018). For example, as the CO2 emissions (t-1) of a country increase, the amount of CO2 released into the atmosphere is affected.

Similarly, CO2 emissions (t-1) show an indirect and positive impact on CO2 emissions through the path emi_c_1 => en_nr => emi_c. This means that a 1% increase in CO2 emissions (t-1) will increase carbon dioxide emissions by 0.34%. It is observed that the volume of CO2 emissions (t-1) influences the volume of CO2 emitted, confirming that CO2 emissions were a variable explained by its lagged value one year earlier.

According to Chu and Le (2022), fossil fuels, including coal, oil, and natural gas, are energy sources that are not replenished on a human timescale. Oil and natural gas are used for transportation and electricity generation, while coal, the most carbon-intensive fossil fuel, accounts for a significant portion of global energy consumption. When these energy sources are burned, they release CO2 into the atmosphere as a byproduct, resulting in an exponential growth trend of CO2 emissions.

The results for the total population show a direct and positive impact on CO2 emissions. This means that a 1% increase in the total population will increase carbon dioxide emissions by 0.21%. Additionally, an indirect and positive influence of the total population through GDP per capita on CO2 emissions was observed through the path pop_c => gdp_c => emi_c. This means that a 1% increase in the total population will increase carbon dioxide emissions by 0.12%. Consistent with the findings of D'Orazio and Dirks (2022) and Kouyakhi (2022).

According to D'Orazio and Dirks (2022), this occurs because larger populations consume more energy, which remains a significant source of CO2 emissions. Additionally, larger populations often require more infrastructure and development, which positively affects their contribution to CO2 emissions.

On the other hand, the total population has an indirect and negative impact on CO2 emissions through the path pop_c => en_nr => emi_c. This means that a 1% increase in the total population will decrease carbon dioxide emissions by 0.23%. Consistent with the findings of Ghosh (2022) and Raza (2022). According to Ghosh (2022), it is not common for the population size to increase while CO2 emissions decrease. However, it is possible that other factors lead to a decrease in CO2 emissions despite an increase in population size. Raza (2022) states that a country with a growing population may also be implementing policies or technologies

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designed to reduce CO2 emissions, or even relying on population awareness to adopt sustainable measures aimed at reducing CO2 emissions.

Thus, institutional theory highlights the importance of institutions, such as governments and companies, in shaping behaviors and energy policies that affect CO2 emissions. For example, government policies incentivizing renewable energy sources and corporate practices aimed at reducing CO2 emissions can contribute to emission reduction relative to population size.

In contrast, the total population has an indirect and positive impact on CO2 emissions through the path pop_c => gdp_c => emi_c. This means that a 1% increase in the total population will increase carbon dioxide emissions by 0.12%. Consistent with the findings of Zhao et al. (2022) and Khan and Yahong (2022). It confirms the indirect effect of the total population in explaining carbon dioxide emissions.

According to Zhao et al. (2022), the relationship between population size and CO2 emissions is complex and varies significantly depending on the specific circumstances of a particular country or region. Population size also indirectly impacts CO2 emissions through its effects on other factors influencing CO2 emissions. For example, population growth leads to urbanization, which increases demand for transportation and contributes to higher CO2 emissions from the transportation sector.

The results of GDP per capita show a direct and positive impact on CO2 emissions. This means that a 1% increase in GDP per capita will increase carbon dioxide emissions by 0.18%. Consistent with research conducted by Zahoor, Khan, and Hou (2022); Baloch (2022); and Rehman et al. (2022). One reason for this relationship is that higher GDP per capita is often accompanied by increased energy consumption and resource use, leading to higher CO2 emissions.

In the case of an increase in GDP per capita, this leads to an increase in energy demand and, consequently, higher CO2 emissions. Additionally, according to institutional theory, the lack of clear regulations and incentives for emission reduction leads to a persistence in dependence on dirty and non-renewable energy sources.

According to Baloch (2022), the extraction, processing, and transportation of raw materials contribute to CO2 emissions. Another aspect, as noted by Zahoor, Khan, and Hou (2022), is that higher GDP per capita is associated with increased consumption, and this relationship contributes to higher CO2 emissions through the production, transportation, and disposal of goods and services.

On the other hand, GDP per capita has an indirect and negative impact on CO2 emissions through the path gdp_c => en_nr => emi_c. This means that a 1% increase in GDP per capita will decrease carbon dioxide emissions by 0.14%. Divergent from the results estimated by Avenyoe and Tregenna (2022), Zhao et al. (2022), and Hamid et al. (2022).

In this context, institutional theory emphasizes that an increase in GDP per capita in a country, associated with a shift in energy priorities and an increase in energy efficiency, results in a reduction in greenhouse gas emissions. However, it is important to note that an increase in GDP per capita is not a guarantee of a reduction in CO2 emissions, as there may be economic and institutional factors sustaining environmentally harmful behaviors.

However, according to Yang et al. (2022), GDP per capita has a dual effect on carbon dioxide emissions; this dual effect establishes a negative relationship between GDP per capita and CO2 emissions. As GDP per capita increases, a shift towards more energy-efficient technologies and practices is observed. For example, the adoption of energy-efficient appliances, buildings, and transportation systems helps reduce energy consumption and CO2 emissions.

In line with Belucio et al. (2022), the growth of GDP per capita prompts inhabitants of countries to make eminent efforts to conserve resources and reduce waste, which also contributes to decreasing CO2 emissions. For instance, the adoption of recycling and reuse programs helps reduce the demand for raw materials, thereby reducing CO2 emissions associated with the extraction, processing, and transportation of raw materials and waste.

According to Han et al. (2022), another important aspect of higher GDP per capita is the accompanying influence on changes in consumer behavior, which contribute to reducing CO2 emissions. For example, increased awareness of environmental issues leads to more sustainable consumption patterns, such as the adoption of low CO2-producing transportation modes and the purchase of environmentally friendly sustainable products.

The results of Private Sector Domestic Credit present a direct and positive impact on CO2 emissions. This means that a 1% increase in Private Sector Domestic Credit will increase carbon dioxide emissions by 0.13%. Consistent with results found by Aljadani (2022) and Obuobi et al. (2022). The relationship between these two variables will depend on how credit is utilized and how the economy in question is structured.

Therefore, institutional theory argues that financial incentives, such as low-interest rates offered by banks to CO2-emitting companies, lead to higher greenhouse gas emissions. Additionally, the lack of adequate regulation in the financial sector contributes to the continuation of environmentally harmful behaviors.

Obuobi et al. (2022) states that the increase in private sector domestic credit tends to increase CO2 emissions in several ways. First, the increased credit

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enables an increase in demand for goods and services, which results in increased production and consequently, CO2 emissions. Furthermore, the increase in credit leads to higher investment in economic activities that generate high CO2 emissions, such as the construction of transportation infrastructure. Finally, the increase in credit under certain circumstances results in higher asset prices and consequently encourages the extraction of natural resources in more CO2-intensive ways, such as mining.

On the other hand, Private Sector Domestic Credit has an indirect and negative impact on CO2 emissions through the pathway cre_c => gdp_c => en_nr => emi_c. The indirect pathway through GDP per capita and non-renewable energy indicates that a 1% increase in Private Sector Domestic Credit will decrease carbon dioxide emissions by 0.33%. Consistent with results found by D'Orazio and Dirks (2022) and Avenyo and Tregenna (2022).

In this context, institutional theory advocates for changes in financial regulations, such as incentives for investments in renewable energies and penalties for CO2-emitting companies, which result in a reduction in greenhouse gas emissions. Furthermore, the theory may point to the importance of more sustainable financial practices and the influence of investors and customers demanding more environmentally responsible behaviors.

According to D'Orazio and Dirks (2022), private sector domestic credit plays an important role in the economic growth of a country as it enables companies and individuals to obtain financing for investment in projects and expand their activities. Thus, when private sector domestic credit is aimed at encouraging innovation and technological change, it favors a reduction in CO2 emissions. Therefore, it will depend on how credit is used by companies and how it affects energy use and greenhouse gas emissions. Additionally, the role of individual actions in reducing CO2 emissions must also be considered.

Similarly, Private Sector Domestic Credit has an indirect and negative impact on CO2 emissions through the pathway cre_c => gdp_c => emi_c. The indirect pathway through GDP per capita also indicates that a 1% increase in Private Sector Domestic Credit will decrease carbon dioxide emissions by 0.33%. Consistent with results found by D'Orazio and Dirks (2022) and Avenyo and Tregenna (2022).

However, the relationship between private sector domestic credit and CO2 emissions will depend on many factors. In line with Avenyo and Tregenna (2022), GDP per capita and private sector domestic credit affect CO2 emissions directly or indirectly, depending on the economic structure of a country and the technology used in the production process. Some examples of how private sector domestic credit contributes to reducing CO2 emissions include investments in more efficient technologies, renewable energy projects, and energy efficiency measures.

In the perspective of institutional theory, norms and regulations are key elements in shaping the behaviors and practices of organizations and individuals. They establish expectations and guidelines for actions, providing incentives and sanctions for desired behavior. In the case of greenhouse gas emissions, norms and regulations can incentivize the reduction of these emissions through policies and programs for energy conservation, use of renewable energy sources, and other initiatives to mitigate the impact of climate change.

It is understood in this context that regulations can impose sanctions on companies that fail to meet emission reduction targets, encouraging them to adopt more sustainable practices. Therefore, institutional theory views norms and regulations as important elements for influencing the behavior of organizations and individuals regarding CO2 emissions.

V. Final Considerations

According to the presented research, the following conclusions are drawn: a) the consumption of renewable energy has a direct and negative impact on carbon dioxide emissions; b) the consumption of non-renewable energy directly and positively affects CO2 emissions; c) the lagged CO2 emissions have a dual effect, but it positively impacts both directly and indirectly on CO2 emissions; d) GDP per capita and private sector internal credit have a dual effect on CO2 emissions, being positive directly and negative indirectly for both; e) the population has a triple effect on CO2 emissions, with a direct positive effect, a positive indirect effect, and a negative indirect effect.

Highlighted is the significant effect of the relationship between non-renewable energy consumption and carbon emission, as a result of human activities such as burning dirty energy in industrial production, agriculture, and other processes. This is justified due to the excessive dependence on traditional fossil fuel energy by most countries, as the use of this type of energy leads to increased CO2 emissions into the atmosphere.

Regarding the effect of the relationship between renewable energy consumption and carbon emission, it is concluded that renewable energy consumption directly and negatively affects CO2 emissions. This is justified by its being an inexhaustible source of energy generated from natural resources that renew continuously, such as the sun, wind, tides, and biomass. Therefore, transitioning to an energy matrix based on renewable sources significantly contributes to reducing CO2 emissions and preserving the environment.

Regarding the causal relationship between economic growth and carbon emission, GDP per capita has a dual effect. First, it directly and positively affects

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CO2 emissions. This magnitude is primarily justified due to the increase in energy consumption necessary to sustain economic growth. Second, GDP per capita indirectly and negatively affects CO2 emissions. This is justified by technological advancements associated with energy efficiency and factors such as behavioral changes among people.

Similarly, a dual effect on carbon emission is also identified for private sector internal credit: firstly, private sector internal credit directly and positively affects CO2 emissions, as an increase in credit in sectors that raise demand for goods, services, or consumer goods contributes to increased production. Conversely, by driving economic growth through GDP, private sector internal credit indirectly impacts carbon emission negatively. This is justified because credit investment in sectors aimed at promoting innovation and technological changes.

On the other hand, CO2 emissions (t-1) have a dual effect, with a direct and positive impact and an indirect and positive impact on carbon dioxide emission. This relationship is justified because as the CO2 emissions (t-1) of a country increase, the amount of CO2 released into the atmosphere is affected.

In the analysis perspective, a triple effect in the relationship between total population and CO2 emissions is confirmed. Firstly, it is concluded that the population directly and positively affects carbon dioxide emissions. This is justified due to the increased demand for transportation, products, and energy; as the population size increases, there is a greater need for infrastructure and industrialized products. Secondly, it is concluded that the total population has an indirect and positive impact on CO2 emissions through the path of GDP per capita. This is justified because as a significant portion of the population in countries engages in economic activities, CO2 emissions are likely to increase. Thirdly, it is concluded that the total population has an indirect and negative impact on CO2 emissions through the path of non-renewable energy. This is primarily justified by the rational use of energy and ecological awareness among the population when adopting sustainable measures.

Based on the presented results, several institutional suggestions stand out: the creation of norms and regulations that encourage the use of renewable energy sources, such as solar panels and wind turbines, to reduce CO2 emissions; financial incentives, such as subsidies and tax credits, to promote the use of clean energy sources and make renewable energy sources more accessible and attractive to companies and consumers; investments in research and development to increase the efficiency and competitiveness of clean energy sources and make renewable energy sources economically viable and therefore widely used; establishment of energy efficiency standards for buildings and vehicles, which contribute to changes in consumption patterns towards renewable energy sources.

Therefore, it is proposed that governments and the general population adopt measures related to the development of alternative energy technologies to promote energy efficiency, especially in industries, buildings, and transportation. Additionally, investing in education, incentivizing behavioral changes, and raising awareness among the population about the impact of CO2 emissions are considered important.

As a strategy to reduce CO2 emissions, the implementation of carbon policies, such as the carbon market, to incentivize emission reductions and investment in carbon capture and storage technologies is highlighted. However, it is worth noting that these measures should be implemented in a balanced manner, taking into account the economic and social needs of each country. Furthermore, the involvement of universities and research centers in this process is crucial to finding systemic solutions to this issue.

Regarding the limitations of the present study, the restricted temporal dimension is mentioned, meaning the lack of complete and precise data; as a result, certain countries were excluded from the analysis. Furthermore, some of these limitations include the difficulty in comparing countries, as CO2 emissions are affected by many factors such as the size of the country, the type of economy, and the level of development, which make a precise comparison of CO2 emissions between countries challenging. Another important aspect relates to the complex interactions among variables that impact and affect CO2 emissions.

Regarding future prospects, it is suggested to add more variables to study the factors influencing CO2 emissions, not only at the macro level, analyzing trends in CO2 emissions globally, regionally, or nationally, but also at the micro level, including identifying key emission sources and evaluating policies and programs to reduce them. Another suggestion for future studies relates to the climatic effects resulting from CO2 emissions, as well as their impacts on human health and ecosystems.

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Governance of Incomes from the Inland Fishing Industry in the Republic of Congo: Analysis by the Catfish Value Chain, Clarias Gabonensis, from the Lac Tele Community Reserve

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Abstract- The results of this study, conducted between July and November 2019, have identified that a *Clarias gabonensis* value chain in the North part of Congo is principally dominated by men with regards to fishing activities and women with regard to the marketing of fish products harvested from the Lac Télé Community Reserve (LTCR) to the cities of Impfondo, Pokola and Oyo. Both the fishing and the marketing are practiced by all age groups in the reserve and others localities. Among fishermen, 20.40% are over 55 years old and 69.60% are between 18 and 54 years old. 34.69% have no education 38.77% have a primary level of education and 26.53% have a secondary level of education. In comparison, wholesalers and retailers have mainly a basic educational level; 30% of the workforce is over 50 and over 70% have more than 10 years of experience in the business. The absence of institutional investment in this value chain is demonstrated by the importance of internal investment, resulting in dependence between the actors.

Keywords: value chain, fishing, governance, added value, profit.

GJHSS-B Classification: LCC: SH240, SH173.5



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Governance of Incomes from the Inland Fishing Industry in the Republic of Congo: Analysis by the Catfish Value Chain, Clarias Gabonensis, from the Lac Tele Community Reserve

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Keywords: value chain, fishing, governance, added value, profit.

I. Introduction

According to [1], the 2030 Agenda for Sustainable Development is the vision of a more just and peaceful world, in which no one is left behind. One of the major challenges in implementing the 2030 Agenda is the sustainability gap between developed and developing countries, which results in part from increasing economic interdependence and the limited capacities of developing countries to develop robust management and governance of food systems. To close this gap, while making progress towards the target of rebuilding overexploited stocks set out in the 2030 Agenda, the international community must help developing countries realize their full potential in the fisheries and aquaculture sectors [2,3];[4]. It is in this vein that, as part of its development policy for the fishing sector and the fight against poverty, the Republic of the Congo has undertaken to sustainably manage its fishery resources by fishing one of its priorities [5]. This is one of the fields of activity that today forms the basis of the livelihoods of the populations living around lakes, rivers and coastal marine areas. The hydrographic network of the Republic of Congo is particularly important and presents significant fishery resources [6]. In order, to make the most of these surface water resources, which are particularly rich in fish, fishing and aquaculture can be much better managed and developed. In Congo, fishing contributes 2.6% of the Gross Domestic Product (GDP) [4]. Unfortunately, it has also produced perverse effects over time. Indeed, clear signs of overexploitation are observed in many fisheries, accompanied by the depletion of certain species in certain bodies of water. It is therefore necessary to reverse these negative trends observed in the fisheries sector, in order to better contribute to the growth and poverty reduction strategy adopted by the country and to adapt the strategic orientations with those of the departmental institutions, sub-regional, regional and international [5]. The use of the value chain as a framework for analyzing artisanal fishing activities is a relatively new fact [7]. The current debate centers on the question of how best to create and distribute gains from economic activities, and how to do this in the context of developing countries [8]. The value chain analysis is an assessment of all the actors and all the factors that participate in the realization of the activities and the relationships created between the participants in order to identify the main obstacles to the improvement of performance, productivity and competitiveness and how these barriers can be overcome [9]. Today, the sustainability of artisanal fishing in the Lac Télé Community Reserve (LTCR) is threatened because it has to face the major challenges posed in particular by environmental degradation, overexploitation of target stocks, seasonality. of production in fishing and mismanagement of shared or uncharged resources [10]. Considering these lacunas related to the production and marketing of *Clarias gabonensis*, we aim here to investigate the following; what is the mode of governance that explains interactions between actors in the *Clarias gabonensis* value chain? Based on the cost and price analysis along the value chain, is the activity profitable ? How is the profit made distributed among the actors in the *Clarias*

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profit made distributed among the actors in the *Clarias gabonensis* value chain, and is it distributed fairly? The main objective of this study which have been done between July and November 2019,was to analyze the value chain of *Clarias gabonensis*, an abundant species in the rivers of the LTCR, in order to determine the mechanisms of creation and distribution of added value in the light of the modes of organization and governance which govern the relations between actors of the value chain in the LTCR and in the towns of Impfondo, Pokola and Oyo. More precisely; analyze the functioning and internal governance of the *Clarias gabonensis* value chain; assess costs, added value and commercial profitability at all stages of the value chain; determine the actors holding a significant share of added value and profit and analyze the constraints and opportunities of the *Clarias gabonensis* circuit from "river to fork".

II. Management and Data Collection

a) Experimental Methodology

The study took place from July to November 2019 in the Lac Télé Community Reserve which is located in the Likouala Department in the far North of the Republic of Congo (Figure 1a) *Video 1.* The reserve has 27 villages which practice fishing. Seven (07) sample villages namely; Mokengui, Epéna, Dzeke, Moumgouma-Bailly, Botongo, Mossengue and Bouanela were randomly selected to host the surveys relating to the study. These villages are the starting point for shipments of *Clarias gabonensis* to supply the towns that revolve around the Reserve. These towns surrounding the LTCR are the main drop-off points for shipments of *Clarias gabonensis* from the LTCR during the period July to November. This is the main reason for their choice. Among them *Video 1;*

- *Impfondo:* Chief town of the Department of Likouala, 33,911 habitants
- *Pokola:* Cosmopolitan city of the Department of Sangha, 10,465 habitants
- *Oyo:* Cosmopolitan city of the Department of Cuvette 14, 950 habitants in reference [18].

We used the reasoned choice survey method, because it makes it possible to conduct a study on a part of the population that has the same characteristics or exercises the same activities. The result obtained can be extrapolated to the entire population [11]. Given the absence of an exhaustive list of actors recognized in the marketing of *Clarias gabonensis* in the sample villages of the LTCR and the target cities of the study, the sample was constituted on the basis of non-probability sampling. A sample of 89 respondents, ie 49 fishermen, 10 wholesalers and 30 retailers were obtained from the different sample sites of the study. These actors were selected based on their availability to answer our questions. The sampling effort was two (02) days in the villages of the LTCR of (09) days on average for the data collection campaign in the cities. The interview time varied between 25 to 30 minutes depending on the availability of the interviewee *Video 2.* During our data collection campaigns, we used several methods and techniques to collect both primary and secondary data relating to the study. Among these methods and techniques, we can cite:

- *Comparative Method:* This method allowed us to compare the added value and the profit along the value chain according to the different stakeholders, the comparison between the prices of the different fishing periods and the comparison of the added value of the stakeholders' value chain.
- *Statistical Method:* The statistical method helped us to quantify the results of the research, then allowed us to present these results in the form of graphs, tables and diagrams, using variables. This method allowed us to facilitate the processing of data collected during our research and the interpretation of this data in a clear manner.
- *Synthetic Method:* This method allowed us to globalize the elements of our work to a coherent whole using a map of the *Clarias gabonensis* value chain according to the sites of the study. The synthetic method also made it easier for us to draw the conclusion from our work.
- *Descriptive or Explanatory Method:* It allowed us to describe our study environment but also to know the behavior of agents in our study environment.
- *Interview Technique:* This technique allowed us to find clear information from the fishermen and traders sampled and some additional information to that which we obtained by questionnaire.
- *Observation:* It allowed us to have additional information on the functioning of the activities of the actors.
- *Documentary Technique:* Documentary technique has opened the sky to the systematic use of certain documents relating to our work. In this work, this technique allowed us to use the various works such as books, reports, and briefs and as well as certain websites relating to fishing activity in the various departments of the country and particularly in the LTCR.
- *Questionnaire Survey Technique:* The questionnaire survey technique is a mean of communicating with the respondent by asking him a series of questions concerning his fishing activity for fishermen or his *Clarias gabonensis* trade activity for traders (wholesalers, semi-wholesalers and retailers). This method allowed us to collect information from those who answered questions asked in an open or

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closed (or mixed) manner about their respective activities in reference [12].

b) Treatment of Data Collected

The data analysis took place in several stages: mapping, analysis of governance in the value chain, analysis of costs, analysis of commercial profitability and analysis of constraints and opportunities in the value chain. [12].

i. *Mapping of the Clarias gabonensis "Ngolo" value chain*

Mapping the value chain was the first step in the analysis. This mapping consisted of creating a visual representation of the connections between actors in the value chain and other market actors. This provided an overview of the actors and their functions in the value chain and of the flow of products along the chain.

ii. *Governance Analysis*

Governance refers to the organization of the value chain and the coordination between actors. It was the second step in this analysis. This analysis was first of all qualitative, based on indicators such as regulations (product quality standards and standards), control, penalties, method of payment (by the buyer and by the seller), and price fixing, the method of financing activities, the participation of women in the value chain and the relationship of trust between the actors.

iii. *Cost Analysis*

Cost analysis was the third element addressed in the data analysis. This analysis was done within each value chain. It consisted in calculating the production and marketing costs for each category of actors participating in the chain. Then, the cost structure, that is to say the analysis of the share represented by each expenditure item in the total costs was made. This allowed the identification of expenditure items on which we can intervene to improve the performance of the actor concerned.

Thus, for all actors, the total costs (TC) are defined by: TC= CV +CF

With CV representing the variable costs: for the fisherman producer (fuel, battery charge, nets, etc.) and for traders (purchase cost of goods sold, other consumption by third parties, smoking costs, etc.) and CF fixed costs (depreciation, taxes and duties, interest paid, other contributions, etc.).

Socio-economic analysis by estimating a few ratios

- Gross margin (MB) Units: Cases, Basins and seals of *Clarias gabonensis* "Ngolo"

GM = TR - TL

GM = gross margin; TR = total recipe and TL = Total Load

- Cost price (CP) Units: Cases, basins and buckets of *Clarias gabonensis* "Ngolo"

CP = BP + DC

CP: Cost Price

BP: Buying Price

DC: Distribution Cost

- Commercial Profitability (CP = Net income/ Turnover)

iv. *SWOT (Strengths, Weaknesses, Opportunities and Threats) Analysis*

The analysis of constraints and opportunities in each value chain was done using the Strengths, Weaknesses, Opportunities, Threats (SWOT) approach. The aim is to gather, analyze and evaluate information and identify the strategic options facing the *Clarias gabonensis* "Ngolo" value chain in the Republic of Congo.

c) Value Chain's Description of Clarias Gabonensis in Republic of Congo

According to the documentary analysis and the accounts of the populations of the LTCR, the production period of *Clarias gabonensis* reaches its peak during the period of the floods in the Likouala-aux-herbes River between July and November within the LTCR. However, it should be noted that during the same period, overall in the LTCR, fishing catches are at the lowest level. This leads to a scarcity of the global fishery resource (period of low production) and a decrease in the number of players in the fishing industry during this period [5]. Conversely, the start of the year period (end of December, January to March) corresponds to the period of high production in the LTCR. During the study carried out in total, 89 actors of the *Clarias gabonensis* value chain of the LTCR were surveyed in the different villages and sample towns visited during the field data collection phase. Figures 1, 2 and 3 respectively illustrate the mapping of the actors and the complexity of the relationships that the actors maintain in the governance of the *Clarias gabonensis* value chain resulting from the LTCR fishing camps for the various towns of Impfondo, Pokola and Oyo. The total workforce and the relative proportions of each actor in the chain are presented in Table 1. Overall, it emerges that fishermen represent 55.05% of this value chain's workforce, retailers 33.7% and wholesalers 11.2%. Tables 2 and 3 present the social profile of each actor in the different towns and villages of the LTCR. From the analysis of these tables, men are mainly represented in the fishing activity, i.e. 89.7% and 10.20% by women. Conversely, the marketing of *Clarias gabonensis* is dominated by women, ie 87.5% against 12.5% represented by men in the activity. The actors who practice this activity are very experienced overall both in fishing and in marketing if we consider age and seniority in the activities. Among fishermen; 20.40% are over 55 years old. 34.69% have no education 38.77% have primary level and 26.53% have secondary level. Most wholesalers and retailers have a basic educational level; 30% of the workforce is over 50 years old and more than 70% have more than 10 years of experience in the business. On the other

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hand, 57.5% have a primary level of education. The fishermen surveyed do not practice agriculture during the high-water season because of the flooding of the agricultural areas in the LTCR, however during the periods of low water of the Likouala-aux-herbes, they diversify their activities in the camps between agriculture, hunting and processing of fishery products, the financing of which is exclusively from own funds. On the other hand, from Table 4, 85.71% of the actors surveyed practice a part-time secondary activity, agriculture of which represents 66.6% in the town of Impfondo against 14.28% who do not. In the town of Pokola; the only man surveyed of the 11 registered actors, practices a secondary activity as a part-time service provider to the "Congolaise Industrielle du Bois (CIB)". The ten (10) women surveyed do not engage in any other activity other than the marketing of fish at the Pokola municipal market. In the city of Oyo; the fourteen (14) women surveyed do not practice any other secondary activity. The initial capital varies from 25,000 FCFA ($ 45.45) to 200,000 FCFA ($ 363.63) regardless of the category of actors and the city where the activity is practiced. However, the activity is 85% financed from own funds regardless of the category of actors whose entire funds come from the spouse's salary. Table 5 summarizes the governance in the *Clarias gabonensis* value chain in the different cities visited. It emerges that with regard to the suppliers of the chain, namely the fishermen; only 12.5% of wholesalers and retailers in the various towns get their supplies directly from fishermen. 42.5% of respondents get their supplies only from wholesalers from the villages of the LTCR. On the other hand, 45% of those surveyed get supplies from both fishermen and wholesalers when they arrive at travel agencies (stations and ports) in the various localities. Of these actors, 17.5% are supplied every day, but 37.5% of the receive the products 3 times a week. Regardless of category and city, 85% of salespeople make their payment by cash (liquidity) against 15% by credit. The surveys carried out within the LTCR prove that it is the fishermen who set the price during exchanges with other players in the chain. Continuing on from the chain, 52.5% of respondents, both wholesalers and retailers affirm that the price is set by wholesalers from the Reserve called locally "BISSOMBELA". On the other hand, 22.5% of players say the price is set after a consensus between the two parties. None of the players have contracted credit with a financial institution (banks or microfinance). 57.5% say they have never been informed about the availability of financing while 27.5% think that accessibility through the procedures is difficult and 15% think that the interests are too high in these financial institutions. Regarding the analysis of costs in the value chain, Table 6 shows the average cost of fixed charges recorded at retailers in each city in the study. So respectively; intermediate consumption consisting of transport as well as taxes in the various places where the *Clarias gabonensis* product is marketed; is 870 FCFA ($ 1.58) / day in the town of Impfondo, 920 FCFA ($ 1.67) / day in the town of Pokola and 815 FCFA ($ 1.48) / day in the town of Oyo. On the other hand, Table 7 shows us this distribution of the fixed charges relating to the marketing of *Clarias gabonensis* from the LTCR fishing camps to the various towns whose average intermediate consumption costs are; 306,000 FCFA ($ 654.54) for a 3-day expedition in the North-East axis of the reserve entering by Epena coming from Impfondo; 416,000 FCFA ($ 1.67) for a 3-day expedition in the North-West axis of the reserve entering by Mboua from Pokola and 492,450 FCFA ($ 895.36) for a 3-day expedition in the South axis of the reserve entering through Bouanela from the city of Oyo. Table 8 presents the grid of purchase prices and cost of the different forms in which *Clarias gabonensis* products are marketed in the various markets visited (photo 3). Overall, the price demarcation margin for a fresh or smoked product is on average 66.6% between the town of Impfondo and Pokola and 70% between Pokola and Oyo. The table 11 presents the price of *Clarias gabonensis* per kg which varied around 1 and 1,2 $ in the reserve villages with a little level in Epena village. At Impfondo, Pokola and Oyo cities, the price per kg varied around 3 and 4 $ and finaly in large urban centers like; Ouesso, Dolisie, Brazzaville and Pointe-Noire, we can suppose that it varied around 5$. Regarding the analysis of commercial profitability, table 9 illustrates the profitability recorded according to the different types of products encountered on the market for a day of sales at wholesalers in each city. It appears that; the commercial profitability in the city of Impfondo for the fresh fish sold in the 40 L and 80 L basins is respectively 22.22% and 23.07% with respective added values of 4000 FCFA ($ 7.27) and 9,000 FCFA ($ 16.36) for a day of sales. In the town of Pokola, the commercial profitability recorded for the smoked Clarias products among others; the 1.5 m^3 case and the 3 m^3 case are respectively 30% and 28.75% with respective values of 4000 FCFA ($ 7.27) and 9000 FCFA ($ 16.36) for a day of sales. In the city of Oyo, smoked products recorded a commercial profitability for the 1.5 m^3 and 3 m^3 cases, then for the 40 L basin was respectively; 36.36%, 37.25% and 50%. Table 10 also illustrates the commercial profitability of these different products generated by retailers in each city. So, in the town of Impfondo; the commercial profitability of the 40 L and 80 L basins were 7.89% and 9.09% respectively with added values of 2,130 FCFA ($ 3.87) and 4,130 FCFA ($ 7.5). For the city of Pokola; the 1 m^3 and 3 m^3 cases recorded returns of 12.5% and 12.22% with added values of 4080 FCFA ($ 7.41) and 6080 FCFA ($ 11.05) and 22.22% and 37.5% for the 1.5 m^3 and 3m^3 cases and 21, 57% for the 40 L basin in the city of Oyo with respectively added values of 9,185 FCFA ($ 16.7), 9,185 (16, $ 7) FCFA and 6,185 FCFA ($ 11.24). Regarding the

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Strengths, Weaknesses, Threats and Opportunities (SWOT) analysis, the development opportunities of the *Clarias gabonensis* value chain in the area (LTCR and Impfondo, Pokola, Oyo) are enormous. The current context marked by the remarkable expansion of world demand for seafood and the stagnation of world production of catches [2],[3],[4] portends very interesting prospects for fishing activity in the villages of the LTCR but also in the various towns which hosted surveys relating to the value chain analysis of *Clarias gabonensis*. However, it is important to respect the principles of sustainable and responsible fishing in order to guarantee the sustainability of the resource in the LTCR, in particular the prescriptions of the existing mini-fishing charter that the fishermen themselves have established.

d) Impacts of Added Value in Livehoods of LTCR Communities

Regarding the social profile of the actors of the *Clarias gabonensis* value chain surveyed, fishing activity in the LTCR is predominantly with 89.7% of men and 10.20% of women regardless of the different sample villages. covered, even if in [13] mentions that the activity knows the participation of all layers of the population (men, women and children). In [10] notes that 50% of fishermen have a secondary school level, 28% a primary level and 14% a university level. These results are close to those we have recorded, namely: 64% primary and 37% secondary. This increase in the number of secondary school education in the villages is explained by the increase in the number of schools between 2006 and 2019. It is also important to note that the activity is more practiced by the elderly. More than 54% of the population of surveyed fishermen are over 60 years old in the villages of the LTCR. This trend is also observed in the profile of the other players in the chain, namely the wholesalers and retailers encountered in the various cities visited. The disinterestedness of young people, for lack of means and support, and the decrease in productivity seem to be the reasons for their low representativeness in the sector of activity. See [14] have observed the same configuration of values chain of Bagrus spp in two famous lakes in Democratic Republic of Congo; Edouard and Albert lakes in spite of different of species which were studied. In the towns of Impfondo, Pokola and Oyo, the "mapping" of the chain actors as well as the different relationships that govern the collaboration are practically identical. At the top of the chain; the fishermen who are often assimilated to the processors since it is the fishermen who transform their products themselves in the fishing camps, then the wholesalers locally called "BISSOMBELA" who supply the localities of the LTCR with products leaving the camps towards the towns passing through the villages. The carriers then come to facilitate the movement of products from production sites to consumption sites and finally, retailers and consumers who are at the end of the chain. This nomenclature of the *Clarias gabonensis* value chain is similar to that of the fish value chain architecture described by [13], however with a particular emphasis on the secondary actors who also frame the activity in like NGOs and much unstructured fishermen's associations. In [10] also mentioned this configuration of the sale of fish in the villages, specifying that the sale is above all direct at more than 72.34% against 27.65% through intermediaries. The work of [5]reinforces this observation on the marketing of fish but with an emphasis on the places of marketing and not on the actors, He presents the typology of the markets encountered in the villages along the Likouala-aux-herbes know ; wholesale markets (which centralize production and redistribute it to remote regions); semi-wholesale markets (located in production and consumption centers) and retail markets (markets in towns and villages which may be bypassed by sales to local consumers). [5], also states that concerning the prices of fresh or smoked fish per kg or per unit of basket, they vary according to the distance of the camp from the villages or towns. This corroborates the results that we obtained during our study where for cases of 1.5 m^3 and 3 m^3 of fresh *Clarias gabonensis*; the added values that were generated were respectively: 4,080 FCFA ($ 8) and 6,018 FCFA ($ 11) in the town of Pokola and 6,185 FCFA ($ 12) and 9,185 FCFA ($ 19) in the town of Oyo. Financial analysis of the overall cost of transport from the fishing camp to the city market CFAF 306,000 ($ 557) from the Northeastern LTCR camps for the town of Impfondo; 416,500 FCFA ($ 758) from the North-West camps of the LTCR for the city of Pokola and 492,450 FCFA ($ 895) from the camps of the southern axis for the city of Oyo) also allows to justify this gross margin recorded in the selling price of the products. According to [5]: “A basin containing 60 to 120 catfish or Parachanna fish can cost 25,000 ($ 45.45) to 50,000 FCFA ($ 91). While a tank of Protopterus with 2 large fish or 5 medium-sized fish costs 30,000FCFA ($ 52.4). Smoked fish is sold in cases; one case can hold 8 to 12 medium-sized fish, or 5 large fish; the price varies from 12,000 ($ 21.81) to 50,000 FCFA ($ 91)”. What is completely identical to the results obtained in the various markets prospected during the surveys, particularly for *Clarias gabonensis*. In reference [10] also mentions this observation in the marketing of fish, specifying that "The price varies with the species, the abundance fish and therefore with the season. It also varies with localities. Thus, the further south you go, the less expensive the fish, with the exception of the town of Epéna". The village of Epena is subject to the law of supply and demand. Being the starting point of the products for the city of Impfondo, district manager, the strong demand both local and external imposes an increase in the costs of the products at the local market level. This would explain the high prices of products in

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the locality of Epena. In short, based exclusively on commercial profitability and the added value generated by the difference in daily turnover and the gross margin resulting from intermediate consumption while combining the strong demand for fishery products in large urban centers and the quality of the offer of the latter such as Ouesso, Oyo, Brazzaville, Dolisie and Pointe-Noire, it appears that the marketing activity of *Clarias gabonensis* regardless of the form generates much more profit at the level of the city of Oyo , followed by the town of Pokola and finally that of Impfondo. Thus, for the town of Pokola; the 1.5 m^3 and 3 m^3 cases recorded respective returns of 12.5% and 12.22% with added values of 4080 FCFA and 6080 FCFA and 22.22% and 37.5% with added values of 9,185 FCFA ($ 16.7) and 10,588 FCFA ($ 19.25) in the city of Oyo. In other words, the commercial profitability in the value chain of *Clarias gabonensis* resulting from the LTCR, increases with the distance between the places of production and the large sites of consumption as well as between the different actors of the value chain of the LTCR *Clarias gabonensis* in particular, fishermen or boat owners, wholesalers or traders and retailers. The same have been made in different sites around the world especially in Sagaing Region, Myanmar and other African countries in reference [15], [16], [17].

III. Conclusion(s)

The Analysis of the Value Chain of fishery products of the LTCR and the towns of Impfondo, Pokola and Oyo, whose *Clarias gabonensis* had the general objective of determining the mechanisms for creating and distributing added value to the light of the modes of organization and governance which govern the relations between the actors of the said chain in the LTCR and its surrounding towns. Questions of knowledge; what would be the mode of governance that governs interactions between actors in the *Clarias gabonensis* value chain in the LTCR? based on cost and price analysis along the value chain, does the activity make a profit? Is the profit thus found distributed fairly? have been asked. The results obtained from this study show that, in view of the analysis of indicators relating to governance; The *Clarias gabonensis* value chain in the LTCR and its surroundings is governed by a mode of governance with a complex network with interrelations between dynamic actors. The analysis of costs and prices on each link in the *Clarias gabonensis* value chain shows that all actors make a profit because their revenues are greater than their costs if we consider that the sale of fishery products does not be done over a long period of time (plus seven (07) days). Along the *Clarias gabonensis* value chain, the profit thus found would be distributed unfairly because the greater part of the profit ends up with the fishmongers, given the ratio between the fishing effort provided and the price of sale of fishing products to wholesalers and so on to retailers. To conduct this analysis and verify the assumptions thus made, surveys of fishmongers, wholesalers and retailers were carried out and the data were analyzed using a descriptive approach. The analytical framework of the study was based on the value chain approach on the one hand and on the other hand on the Strengths, Weaknesses, Opportunities and Threats (SWOT) approach for the analysis of constraints and opportunities of the *Clarias gabonensis* value chain. At the end of this study, we can retain the following results:

Clarias gabonensis value chain is predominantly dominated by women than men as most women engage in marketing rather than production activities.

Along the *Clarias gabonensis* value chain, only fishermen are grouped together in professional associations, but in practice these associations do not take any action for the development of fishermen;

Generally, the purchase and sale prices are fixed after negotiation between the actors and that the quantities exchanged depend on the fishing period.

All of these features of the *Clarias gabonensis* value chain briefly present the extent of opportunities, but also threats to fishing activity in the LTCR wetlands. However, the majority of the wetlands of the forests encountered in the Congo Basin practically know the problem of the scarcity of resources in general and of fishery resources in particular, the contribution of which in forest life cycles is fundamental. They are unrecognized or even less valued than other resources, which are however also crucial for the survival of the Congo Basin and for the Sustainable Development of the populations who depend on them. A few scientific journals make it a major concern, such as the Scientific Journal "Sustainability", the aim of which is to highlight the results of the work and expertise of researchers and forestry professionals in all the aspects and phenomena of the Basin's forests of the Congo and the challenges of their use. It is for this reason that by way of recommendations;

To the Congolese State to strengthen decisions related to the regulation of fishing activity, management and protection of stocks, prohibit gillnet, limited and prevent fishing in the spawning grounds of the LTCR;

Set up a reliable information system on the market allowing the dissemination of information on the production and price of *Clarias gabonensis* and other species in the different markets surveyed in the towns of Impfondo, Pokola and Oyo;

- Promote the diversification of fishing activities and other sectors such fish culture;
- It is up to fishermen's organizations to put in place a synergy of consultation between associations so that the interests of fishermen are at the center of any development approach and supervision of the sector;

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– To NGOs, in particular to the NGO Wildlife Conservation Society (WCS) co-responsible for the LTCR; build the capacities of stakeholders through training and popularization of new techniques on fishing, processing and marketing of *Clarias gabonensis* responding to consumer preferences, in particular compliance with the requirements of the mini-fishing charter established in collaboration with the fishermen.

Videos Materials

Video 1 available from:

https://www.linkedin.com/posts/eric-bertin-ndzana-biloa-257a23a6_governance-activity-6775401703870218241-J0Ij?utm_source=share&utm_medium=member_desktop

Video 2 available from:

https://clipchamp.com/watch/y1hlIBMAFzy

IV. Appendices and Nomenclature

ERAIFT: Ecole Regional Post-Universitaire en Aménagement des Forêts et des Territoires Tropicaux

WCS: Wildlife Conservation Society

LTCR: Lac Télé Community Reserve

FAO: Food and Agriculture Organization

GDP: Gross Domestic Product

TC: Total Cost

CV: Cost variable

GM: Gross margin

TR: Total Receipe

TL: Total load

CP: Cost Price

BP: Buying Price

DC: Distribution

SWOT: Strengths, Weaknesses, Opportunities, Threats

CV: Chain Value

CIB: Congolaise Industrielle de Bois

FCFA: Franc des Communautés Financières Afrique

NGO: Non Govrenmental Organization

m^3: meter cube

m^2: meter square

L: liter

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Conflict of Interest

The authors declare no conflict of interest.

Notes/Thanks/Other Declarations

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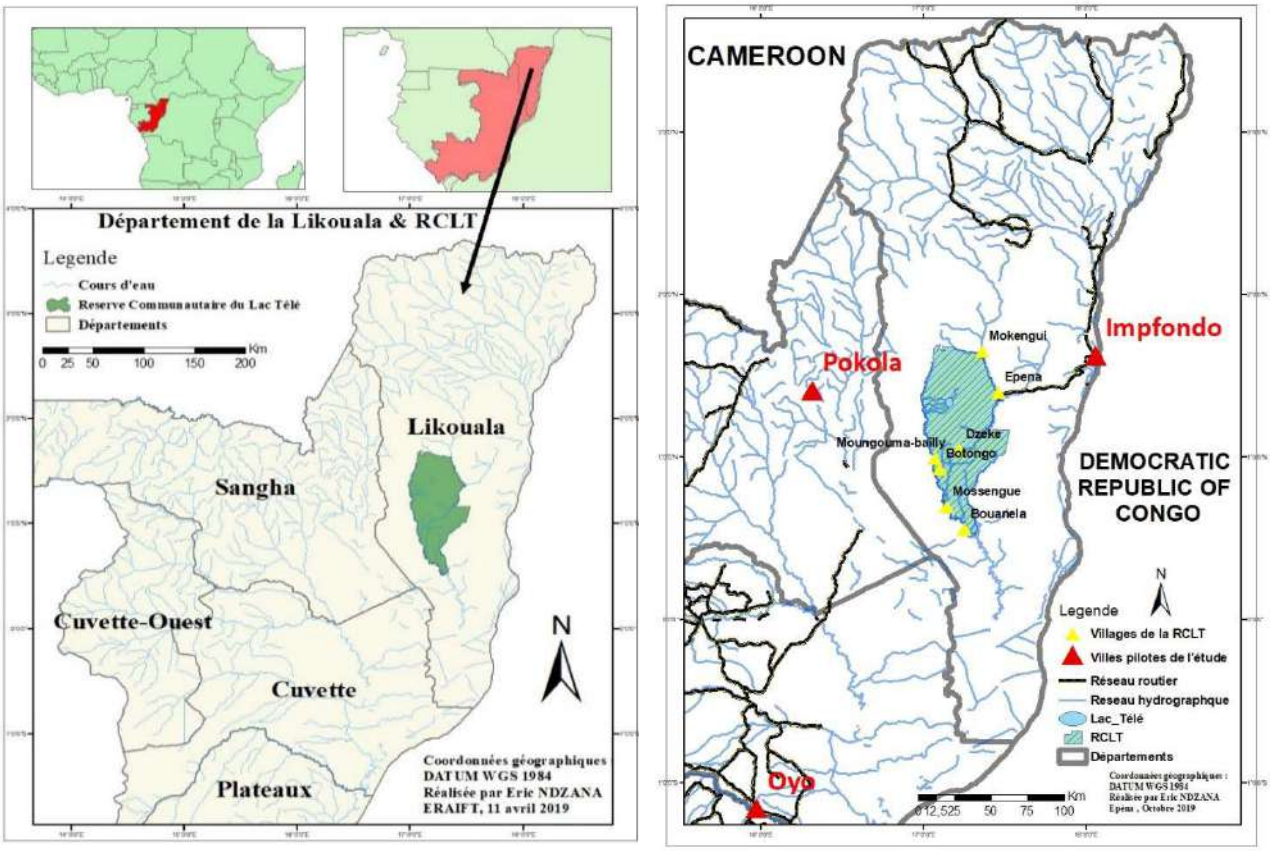

(a) (b)

Figure 1: Location of the Department of Likouala (a), Pilot Towns and Villages (b) of the Study

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(a) (b)

Figure 2: View of the *Clarias gabonensis* Markets from the Bus Station in Impfondo (a) and the Habor Market in Oyo (b)

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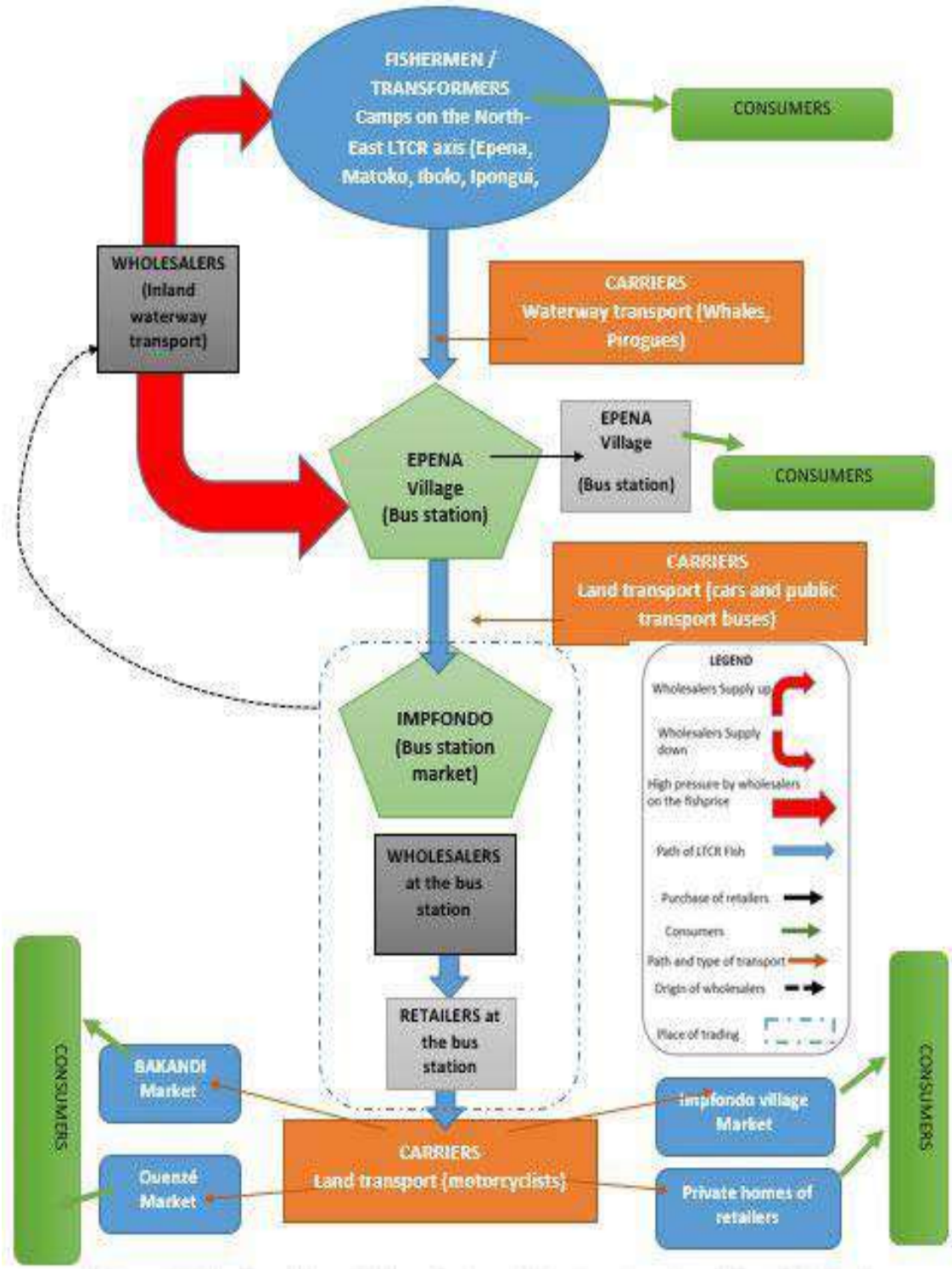

Figure 3: Mapping of Tracability and Actors Influencing the Value Chain of *Clarias gariepinus* from LTCR to Impfondo City

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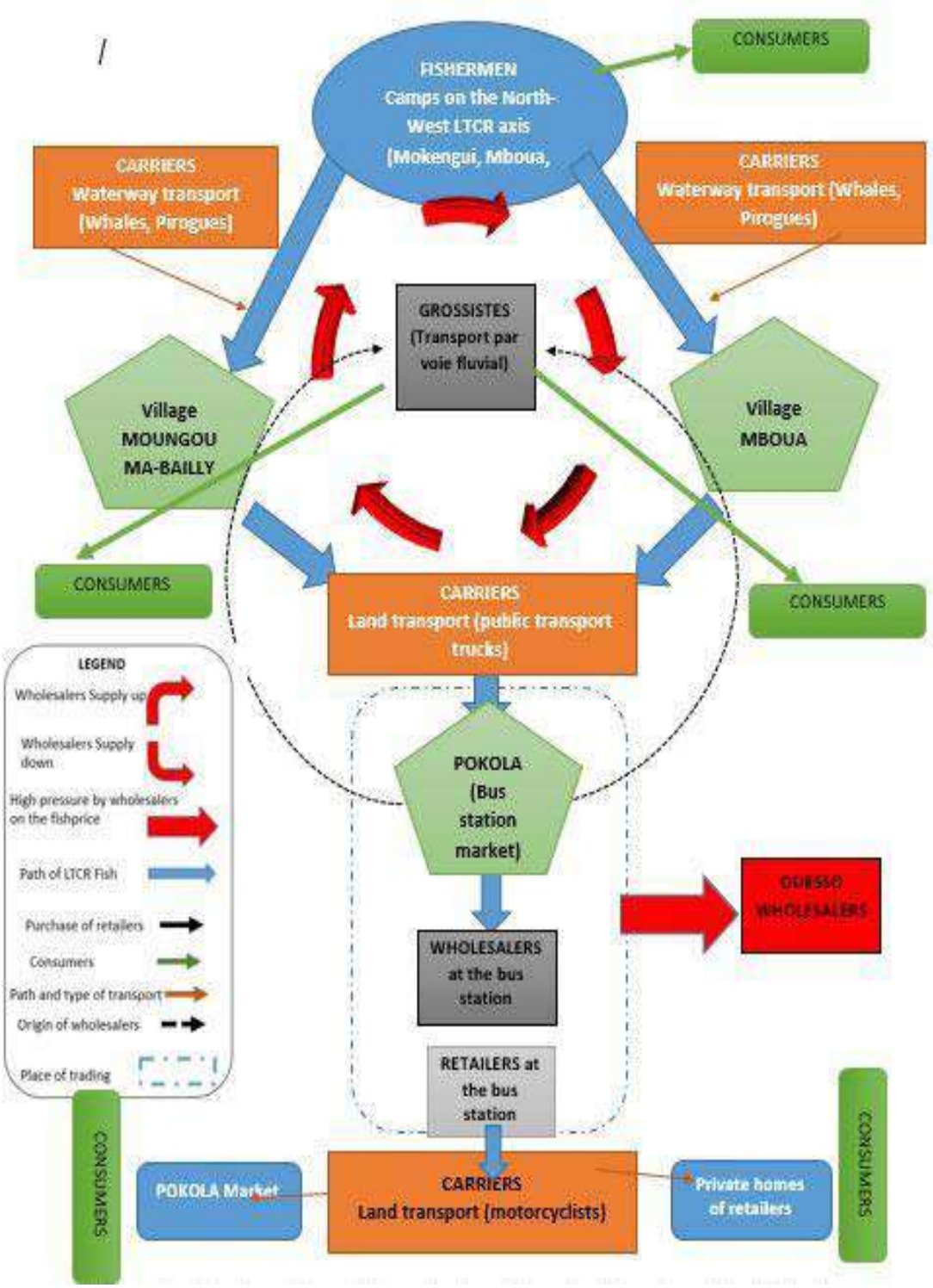

Figure 4: Mapping of Tracability and Actors Influencing the Value Chain of *Clarias gariepinus* from LTCR to Pokola City

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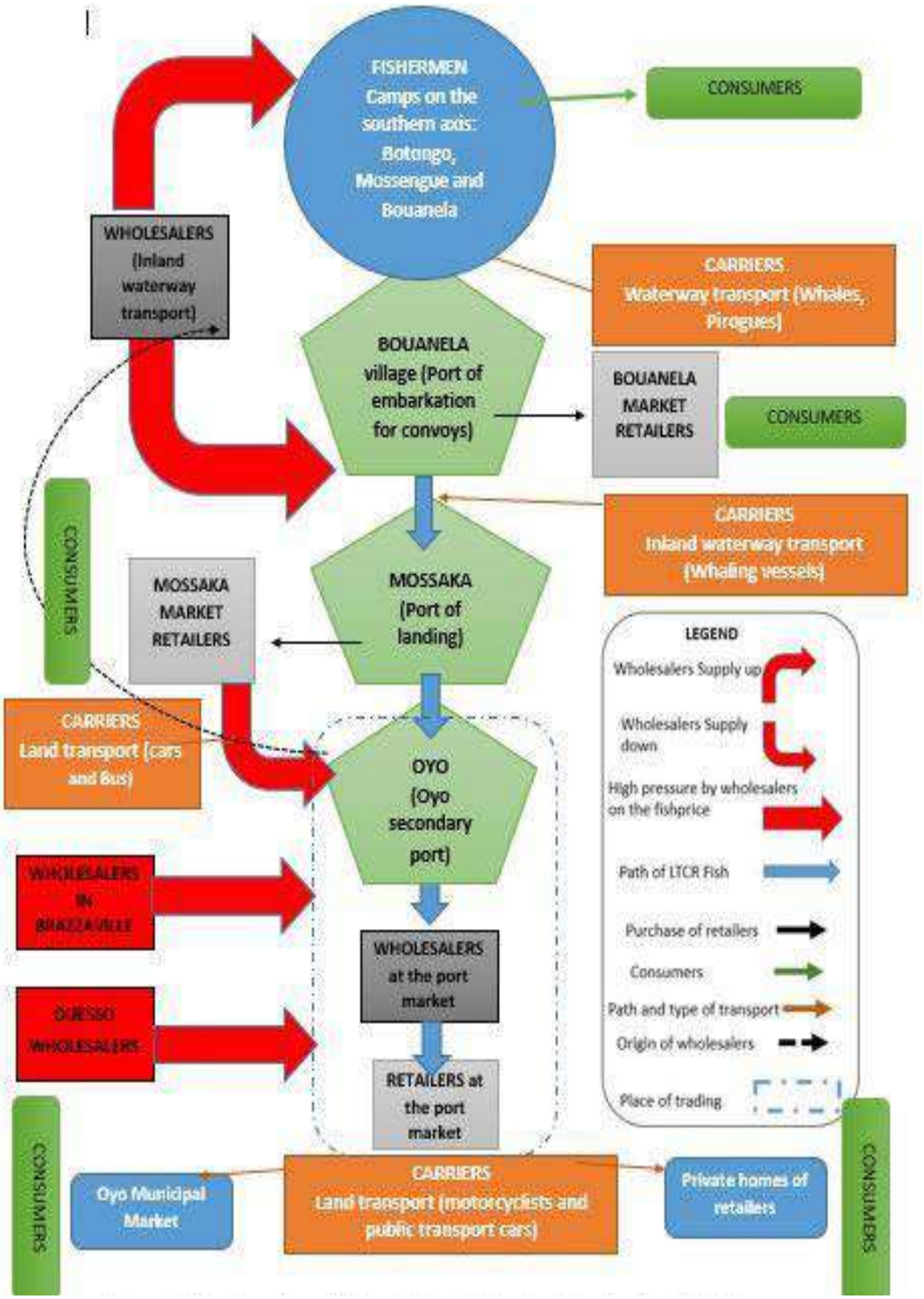

Figure 5: Mapping of Tracability and Actors Influencing the Value Chain of *Clarias gariepinus* from LTCR to Oyo City

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Table 1: Total Workforce and Percentages of Actors in the *Clarias gabonensis* Value Chain in the North of R Congo

Towns Chain' Actors	Impfondo	Pokola	Oyo	TOTAL	Pourcentages (%)
Wholesalers	3	2	5	10	11,2
Retailers	7	9	14	30	33,7
TOTAL				40	44,9
Fishermen in LTRC				49	55,05
TOTAL				89	100

Table 2: Description of the social characteristics of fishermen in the LTCR, R Congo

Variables	Fishermen Surveyed	TOTAL Ni	%
Gender	Men	44	89,7
	Women	5	10,20
Civil statut	Single	14	28,5
	Engaged	35	71,4
	Married	0	0
	Divorcied	0	0
Age	less than de 20 (old)	5	10,20
	21-25	8	16,32
	26-30	8	16,32
	31-35	5	10,20
	36-40	3	6,12
	41-45	6	12,2
	46-50	6	12,2
	51-55	3	6,12
	More than 55 old	10	20,40
level instructions	Any	17	34,69
	Primary	19	38,77
	Secondary	13	26,53
	University	0	0

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Table 3: Description of the Social Characteristics of Wholesalers and Retailers in the North East of R Congo (1$= 550 CFA)

Variables	towns	Impfondo				Pokola				Oyo				TOTAL	
		Wholesalers		Retailers		Wholesalers		Retailers		Wholesalers		Retailers			
Actors surveyed		Ni	%	Ni	%	Ni	%	Ni	%	Ni	%	Ni	%	Ni	%
Gender	Men	1	33,3	0	0	1	50	1	11,1	2	40	0	0	5	12,5
	Women	2	63,7	7	100	1	50	8	88,8	3	60	14	100	35	87,5
Civil status	Single	0	0	1	14,2	0	0	1	11,1	2	40	3	21,4	7	17,5
	Engaged(e)		100	6	85,7	1	50	4	33,3	3	60	7	50	24	60
	Married	0	0	0	0	1	50	4	44,4	0	0	4	28,5	9	22,5
Age	less than 20 old	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	21-25	1	33, 3	0	0	0	0	0	0	0	0	0	0	1	2,5
	26-30	0	0	1	14,2	0	0	0	0	0	0	0	0	1	2,5
	31-35	2	63,7	1	14,2	0	0	0	0	1	20	1	7,14	5	12,5
	36-40	0	0	3	42,8	1	50	1	11,1	1	20	0	0	6	15
	41-45	0	0	0	0	0	0	0	0	0	0	5	35,7	5	12,5
	46-50	0	0	2	28,5	0	0	3	33,3	1	20	4	28,5	10	25
	51-55	0	0	0	0	1	50	2	22,2	2	40	2	14,2	7	17,5
	more than 55 old	0	0	0	0	0	0	3	33,3	0	0	2	14.2	5	12,5
level of instructions	Any	0	0	0	0	0	0	1	11,1	0	0	1	7,14	2	5
	Primary	0	0	4	57,1	0	0	3	33,3	4	80	12	85,7	23	57,5
	Secondary	3	100	3	42,8	2	100	5	55,5	1	20	1	7,14	15	37,5
	university	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ni= Number of individuals %= Percentages or proportion

Table 4: Descriptive statistics of seniority, possession of a secondary activity, origin of capital and initial capital in the North East of R Congo.

Variables	Towns	Impfondo				Pokola				Oyo				TOTAL	
		Wholesalers		Retailers		Wholesaler		Retailers		Wholesalers		Retailers			
Actors Surveyed		Ni	%	Ni	%	Ni	%	Ni	%	Ni	%	Ni	%	Ni	%
Seniority in Activity (old)	1	1	33,33	0	0	0	0	0	0	0	0	1	7,14	2	5
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	1	33,33	0	0	0	0	0	0	0	0	0	0	1	2,5
	5	0	0	2	28,57	0	0	1	11,1	0	0	1	7,14	4	10

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	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0	0	1	7,14	1	2,5
	8	0	0	0	0	0	0	1	11,1	1	20	0	0	2	5
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	1	20	1	7,14	2	5
	Over10	1	33,33	5	71,42	2	100	7	77,7	3	60	10	74,4	28	70
Possession of Secondary Activity	Yes	3	100	6	85,71	2	100	1	11,1	4	80	0	0	16	40
	No	0	0	1	14,28	0	0	8	88,8	1	20	14	100	24	60
	Farmer	1	33,33	4	66,66	2	100	0	0	1	25	0	0	8	53,3
	Hunter	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Artisan	1	33,33	0	0	0	0	0	0	0	0	0	0	1	6,6
	Breeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Saler	1	33,33	2	33,33	0	0	0	0	2	50	0	0	5	33,3
	Carrier	0	0	0	0	0	0	0	0	1	25	0	0	0	0
	Provider service CIB	0	0	0	0	0	0	1	100	0	0	0	0	1	6,6
Origine du capital		0	0	2	0	1	0	0	0	0	0	0	0	3	7,5
	Credit	2	0	5	0	0	0	9	100	4	0	14	100	34	85
	Equity	1	0	0	0	1	0	0	0	1	0	0	0	3	7,5
	Family loan	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Capital	Towns	Impfondo				Pokola				Oyo			
Initial	Actors	Ni	Min	Max	Med	Ni	Min	Max	Med	Ni	Min	Max	Med
(FCFA)	Wholesalers	3	25000	50000	37500	2	10000	150000	125000	5	25000	200000	112500
	Retailers	7	25000	150000	87500	9	10000	500000	225000	14	10000	100000	55000

Ni= Number of individuals %= Percentage or proportion Min = Minimum Max = Maximum Med= Median

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Table 5: Descriptive Statistics of the Mode and Frequency of Supply, the Mode of Payment, Market Pricing, Access to Credit and the Reason for Inaccessibility to Credit in the North East of R Congo

Variables	Towns	Impfondo				Pokola				Oyo				TOTAL	
		Wholesalers		Retailers		Wholesalers		Retailers		Wholesalers		Retailers			
	Actors Surveyed	Ni	%	Ni	%	Ni	%	Ni	%	Ni	%	Ni	%	Ni	%
Supply Market	Fishermen	2	66,6	0	0	2	100	0	0	1	20	0	0	5	12,5
	OtherWholesalers	1	33,3	7	100	0	0	3	33,3	0	0	6	42,85	17	42,5
	Retailers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fishermen Wholesalers	0	0	0	0	0	0	6	66,6	4	80	8	57,14	18	45
Supplying Frequency per Week	Everyday	1	33, 3	4	57,1	0	0	2	22,2	0	0	0	0	7	17,5
	3 times/week	0	0	0	0	1	50	4	44,2	0	0	0	0	5	12,5
	2 times/week	0	0	0	0	1	50	3	33,3	2	40	9	64,28	15	37,5
	1 time /week	0	0	2	28,5	0	0	0	0	3	60	4	28,57	9	22,5
	3 times/month	1	33,3	1	14,2	0	0	0	0	0	0	1	7,14	3	7,5
	2 times/month	1	33,3	0	0	0	0	0	0	0	0	0	0	1	2,5
Payement mode	Crédit	0	0	0	0	0	0	4	44,4	0	0	2	14,28	6	15
	Cash	3	100	7	100	2	100	5	55,5	5	100	12	85,7	34	85
Establishe-ment of price	State	2	66,6	0	0	0	0	0	0	0	0	0	0	2	5
	Fshermen	1	33,3	0	0	2	100	0	0	4	80	1	7,14	8	20
	Wholesalers	0	0	4	0	0	0	4	44,4	1	20	12	64,28	21	52,5
	Consensus	0	0	3	0	0	0	5	55,5	0	0	1	7,14	9	22,5
Access to Crédit	Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	No	3	100	7	100	2	100	9	100	5	100	14	100	40	100
Rasons of Inaccessibility of Crédit	Don't need	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Difficult Access	3	100	1	0	0	0	4	44,4	1	20	2	14,28	11	27,5
	Interesttoo high	0	0	4	0	0	0	1	11,1	1	20	0	0	6	15
	No informations	0	0	2	0	2	100	4	44,4	3	60	12	85,71	23	57,5

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Table 6: Table of Fixed Charges Borne by Retailers on the Market in the Various Cities of North East, R Congo *(1$= 550 CFA)*

Variables	Towns	Impfondo				Pokola				Oyo				TOTAL	
		Modalities		c		Modalities		Retailers		Modalities		Retailers			
Actors surveyed		Unit	Cost	Ni	%	Unit	Cost	Ni	%	Unit	Cost	Ni	%	Ni	%
Fixed charges (FCFA)	Warehouse	/day	100	0	0	/day	100	0	0	/day	250	3	21,42	3	10
	Hygien	/day	100	7	100	/ day	100	9	100	-	-	-	-	30	100
	security	/ day	100	0	0	/day	100	0	0	/mois	1000	14	1000	14	46,6
	Market place rental	/an	25000	7	100	/mois	3500	9	100	/an	10000	14	100	30	100
	Transport to the point of sale	/day	500	7	100	/day	500	9	100	/day	500	14	100	30	100
Average cost fixed	TOTAL (FCFA/day)		870				920				815				

Table 7: Grid of fixed charges borne by wholesalers throughout the LTCR chain to various cities *(1$= 550 CFA)*

Variables	Areas LTCR	Axis Nord-Est				Axis Nord-Ouest				Axis Sud			
		Modalities				Modalities				Modalities			
Fixed Charges		Unit	Q	U. P.	T.C	Unit	Q	U.P.	T.	Unit	Q	U.P.	T.C.
Fixed transport charges in the areas to be covered in LTCR (FCFA)	Fuel	L	250	1000	250000	L	300	1000	300 000	L	350	1000	350 000
	Engine oil	/L of fuel	10	2500	25000	/L of fuel	12	2500	30 000	/L of fuel	14	2500	35 000
	Canoerental	unit	1	10000	10000	unit	1	10000	10 000	unit	1	10 000	10 000
	Engine rental (15 CV)	unit	1	25000	25000	unit	1	25000	25 000	unit	1	25 000	25 000
	Pinassier service	men /day	1	10000	10 000	men /day	1	10000	10 000	men /day	1	10 000	10 000
TOTAL		3 days expedition			300000				405000				450 000

Variables	Towns	Epena-Impfondo (2h30)				Mboua-Pokola (Mi-day)				Bouanela-Oyo (3 to 4 days)			
		Modalities		wholesalers		Modalities		Wholesalers		Modalities		Wholesalers	
Actors surveyed		Unit	Cost	Ni	%	Unit	Cost	Ni	%	Unit	Cost	Ni	%
Fixed charges Related to travel to cities (CFA)	Transport	Aller- go-back	5000	3	100	go-back	10000	2	100	go-back	40 000	5	100
	Handling	flat rate	1000	0	0	flat rate	1000	0	0	flat rate	2000	5	100
	Storage	0	0	0	0	0	0	0	0	flat rate	450	5	100
Averagecost	TOTAL		6000				11000				42450		

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Table 8: Sale Price of Fresh and Smoked *Clarias gabonensis* at Wholesalers and Retailers in the Various Towns of North East, R Congo

Variables	Towns	Impfondo				Pokola				Oyo				TOTAL	
		Modalities		Wholesalers		Modalities		Wholesalers		Modalities		Wholesalers			
Actors Surveyed		Unit	Cost	Ni	%	Unit	Cost	Ni	%	Unit	Cost	Ni	%	Ni	%
«Ngolofresh »	Can of	25 L	10000	0	0	25 L	15000	0	0	25 L	20000	0	0	0	0
	Basin	40 L	35000	1	33,3	40 L	40000	0	0	40 L	45000	2	40	3	30
	Pot of	80 L	50000	2	66,6	80 L	60000	0	0	80 L	75000	0	0	2	20
«smoked Ngolo »	Basket	1,5 m^3	15000	0	0	1,5m^3	35000	1	50	1,5 m^3	35000	1	20	2	20
		3 m^3	30000	0	0	3 m^3	50000	1	50	3 m^3	60000	2	40	3	30
		5 m^3	55000	0	0	5 m^3	65000	0	0	5 m^3	75000	0	0	0	0

Table 9: Estimation of commercial profitability at wholesalers in different cities of the North East (R. Congo) for a day of sale (1$= 550 CFA)

Towns		**Impfondo**			**Pokola**			**Oyo**		
		Type of products			**Type of products**			**Type of products**		
Indicators		**Unit**	***Fresh Clarias***		**Unit**	***Smoked Clarias***		**smoked*Clarias***		***FreshClarias***
Quantity sold / day		**Basin**	**Basin of 40 L**	**Basin of 80L**	**basket**	**basket of 1,5m^3**	**basket of 3,5m^3**	**basket of 1,5m^3**	**basket of 3,5m^3**	**1basin of 40 L**
Unit purchase price		FCFA / basin	35000	50 000	FCFA / Claie	35000	50 000	35000	50 000	25 000
Unit selling price		FCFA / basin	45000	65 000	FCFA / Claie	50 000	70 000	55 000	80 000	50 000
Commercial margin		FCFA	10 000	15 000	FCFA	15 000	20 000	20000	30 000	25 000
Commercial profitability (%)			**22,22**	**23,07**		**30**	**28,57**	**36,36**	**37,5**	**50**
Consumers Intermediaries	**Transport**	FCFA	**6000**	6000	FCFA	11 000	11 000	42 450	42 450	42 450
	TOTAL (CI)	FCFA	6000	6000	FCFA	11 000	11 000	42 450	42 450	42 450
Added value		**FCFA**	**4000**	**9000**	**FCFA**	**4000**	**9000**	**-22 450**	**-12 450**	**-17 450**

Table 10: Estimation of commercial profitability at retailers in different cities of the North East (R. Congo) for a day of sale *(1$= 550 CFA)*

Towns		Impfondo			Pokola			Oyo		
		Type of Products			Type of Products			Type of Products		
Indicators		Unit	Fresh Clarias		Unit	Smoked Clarias		Smoked Clarias		Fresh Clarias
Quantity sold / day		Basin	Basin of 40 L	Basin of 80 L	Basket	Basket of 1,5 m^3	basket of 3,5 m^3	basket of 1,5 m^3	Basket of 3,5 m^3	Basin of 40 L
Unit purchase price		FCFA / bassine	35000	50 000	FCFA / Claie	35000	50 000	35000	50 000	25 000
Unit selling price		FCFA / bassine	38 000	55 000	FCFA / Claie	40 000	57 000	45 000	60000	32 000
Commercial margin		FCFA	3 000	5 000	FCFA	5 000	7 000	10000	10 000	7 000

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Commercial profitability (%)			**7,89**	**9,09**		**12,25**	**12,22**	**22,22**	**37,5**	**21,87**
Consumers Intermediaries (CI)	**Transport**	FCFA	**500**	**500**	FCFA	500	500	500	500	500
	Taxes	FCFA	370	370	FCFA	420	420	315	315	315
	TOTAL	**FCFA**	**870**	**870**	**FCFA**	920	920	815	815	815
Added value		**FCFA**	**2130**	**4130**	**FCFA**	**4 080**	**6080**	**9185**	**9185**	**6185**

Tableau 11: Price of *Clarias gabonensis* per kg in different cities of the North East (R. Congo during rain season in CFA (1$= 550 CFA)

Type of retailers	CFA Type of products	CRLT Villages (exceptEpena)		Epena village		Impfondo		Pokola		Oyo	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Retailers in the market	« Fresh Ngolo »	200	500	550	700	1000	1500	*	*	*	*
	« Smoked Ngolo »	550	800	500	1000	1500	2000	1500	2000	1500	1800
Retailers at home	« Fresh Ngolo »	300	550	800	1500	1200	1600	*	*	*	*
	« Smoked Ngolo »	550	800	1200	1700	1500	2000	1700	2000	2000	2500

Min= Minim Max = Maximum * = No fresh *Clarias gabonensis* because of best before date

Table 12: SWOT Analysis of the *Clarias gabonensis* Value Chain in the Various Towns Around the Sample Villages of the LTCR

Strengths	Weaknesses	Opportunities	Threats
Existence of an increasingly demanding local, national, regional and global market	The precariousness of fishing (Fishing is still artisanal)	New political orientations for the development of the sector based on: the rational management of the fishery resource,	Lack of access to financing and credit from financial institutions (banking and microfinance)
The availability of labor at a lower cost.	The approximate management of the fishery resource.	Funding of several fishing and aquaculture projects in the LTCR by the World Bank	Lack of an information system, particularly in the villages of the LTCR
Profit realization by all actors in this value chain.	The absence of the landing infrastructure necessary to preserve quality	New perspectives offered by the country within the framework of free trade agreements in the CEMAC sub-region	The decline in the stock of biomass available following the fishing effort concentrated on *Clarias gabonensis*
Existence of a sustainable fisheries charter in the LTCR and an internal financing system	Processing techniques are still rudimentary (carbonization of specimens of *Clarias gabonensis*)	Strengthening of agricultural sector development policies for the diversification of the country's economy	Lack of an associative dynamic in the different villages of the LTCR
The actors operate in relationships of trust.	Lack of means of preservation, storage and processing	Geostrategic position of the LTCR in the sub-region (Cameroon, CAR, DRC and Gabon)	Low rate of youth participation in agro-pastoral development, particularly in fishing
Experience of the actors in the exercise of their activities.	Failure to comply with price regulations during periods of high and low production	Possibility of developing a label specific to *Clarias gabonensis* from the LTCR	Increase in poaching and commercial hunting in the LTCR
Technical support for fishermen in the reserve through the LTCR project	the low level of qualification of casual labor	Potential development of aquaculture to strengthen fishing activity	Temporal and discontinuous support for fishermen in the LTCR

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The Overview of Environmental Regulation – Brazil and the United States of America

By Guilherme Berndsen

Abstract- The article will present the growth of Environmental Law in the last decades and its practical repercussions with the consequent application of Environmental Law in the domestic scenarios in Brazil and in the United States of America, providing a presentation of the main environmental rules, such as the Federal Constitution of Brazil, the Fauna Protection Law, the National Water Resources Policy, and the Brazilian Forest Code, the National Environmental Policy Act, Clean Air Act, Clean Water Act, combining Doctrines on environmental matters and some of the Leading Cases in Environmental Law, in particular, Citizens Can Preserve Overton Park, Inc. v. Volpe – 401 US 402 (1971), Massachusetts v. EPA, 549 US 497 and Direct Action of Constitutionality (ADC) 42 and other Mandatory Precedents that brought new environmental debates and helped to incorporate good results in the domestic scenario of each country in the environmental field.

Keywords: environment, pollution, judicialization, environmental statutes, sustainability.

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Introduction

The Brazilian Federal Constitution of 1988 had as a paradigmatic milestone the elevation of the protection of the environment as a constitutional value in the legal system. In its article 225, the Brazilian Constitution expressly provides that it is everyone's right an ecologically balanced environment and establishes to both the community and the Government the duty to protect and preserve it.

The Constitution of the Brazilian Republic, more precisely, in title VIII, called "On the Social Order", chapter VI, called "On the Environment", in its article 225, provides, that:

> Everyone has the right to an ecologically balanced environment, a good for the common use of the people and essential to a healthy quality of life, and the public authorities and the community have the duty to defend and preserve it for present and future generations.[1]

As a result, the constitutional protection of the environment was broadly and integrally attributed to all Brazilians, deserving the special attention of the legal, social, and political community on national soil, with the Federal Supreme Court, guardian of the Federal Constitution, being responsible for the last analysis of environmental cases in Brazil.

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[1] BRASIL, *Constitution of the Federative Republic of.* of October 5, 1988. Available: http://www.planalto.gov.br/ccivil_03/constituicao/ConstituicaoCompilado.Htm#adctart107i. Access: Sept. 2023.

> With the promulgation of the Brazilian Constitution of 1988, for the first time in the political history of Brazil, there was the existence of its own chapter in relation to the environment, including considering it a good for the use of the people and essential to the quality of life, imposing on the Government and the community the duty to preserve and defend it, for present and future generations.[2]

It should be noted that the environmental protection provided for in article 225 of the Federal Constitution is not isolated, since this article dialogues with numerous other constitutional provisions, such as: ecological function of rural property, provided for in article 186, II, which provides for the "adequate use of available natural resources and preservation of the environment" in rural property, among countless other cases.

In this sense, would be the communication between fundamental social rights and the fundamental right to the environment, which is also one of the central objectives of the concept of sustainable development in the horizon constituted by the Socio-environmental State of Law, to the extent that, together with the idea of environmental protection, also present in its central objective is the fulfillment of the basic needs of the world's poor and the equitable distribution of natural resources (e.g. access to water, food, etc.).[3]

The Brazilian Federation, therefore, has, as a fundamental characteristic, the definition of functions and duties to ensure the fundamental rights and guarantees of people, which meet the fundamental objectives of building a just and solidary society, promoting full citizenship and the dignity of the human person, under the exact terms of article 3, I, of the Federal Constitution.[4]

Now it is up to the entire Brazilian society, and not only to jurists who embrace environmental causes, to turn the constitutional text into true legal norms to be followed and respected, becoming a true foundation of the legal system, under penalty of turning environmental protection into just a poetic text and environmental conflicts into unresolved problems.

[2] MEIRELLES, Hely Lopes. *Brazilian Administrative Law.* São Paulo: Malheiros Editors Ltda, 2000. P. 530.

[3] FENSTERSEIFER, Tiago**.** *Fundamental Rights and Environmental Protection. The ecological dimension of human dignity in the legal-constitutional framework of the Socio-Environmental Rule of Law.* Porto Alegre: Lawyer's Bookstore. Publisher, 2008. P. 74

[4] Article 3º: The fundamental objectives of the Federative Republic of Brazil are I - to build a free, fair, and solidary society; [...]

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It is important to mention that environmental protection is going through a new moment, due to the new socio-environmental problems that humanity is facing, for example, climate change, deforestation and pollution of waters and territories, which cause direct injury to the fundamental rights of countries in general, as well as human rights in a broad and unrestricted way.

In the United States of America, although there is no express reference to environmental protection in the text of the Constitution, environmental law has begun to reflect a sense of community, in which the health and safety of individuals are as important as the economic well-being of a nation.

By the 1930s, most states had already adopted administrative programs to control pollution, but regulatory measures were generally quite ineffective. States were reluctant to impose the cost of better environmental treatment on local governments and private individuals, as they feared leading industries to flee elsewhere.

It was not until the edition of the National Environmental Policy Act of 1969 (NEPA) that a true national policy was established to ensure that all American citizens had the right to a safe, healthy, and productive environment, as included in the Clean Air Act and the Clean Water Act, two major U.S. statutes that are historic milestones in American environmental defense and protection.

The statute is implemented by the Environmental Protection Agency (EPA), several interstate agencies, fifty states (and several territories), and thousands of local governments.[5] Thus, environmental regulations have often begun to be challenged, providing a large role for the courts and litigants, as they are open not only to the regulated industry, but also to environmental groups and others who have environmental claims.

Lawsuits by U.S. citizens over the past thirty-five (35) years have had an enormous impact on improving government compliance with environmental law and encouraging government agencies to implement statutes in creative and expansive ways. In other words, American society, through its citizens, had a new expanded role in the governance of the environment.

Therefore, the use of litigation by environmentalists became increasingly common, because instead of seeking a sweeping transformation of the statutes through rules slower and more time-consuming, environmentalists increasingly began to turn to the courts to enforce and maintain the legislative victories they had won in the past.

Consequently, it can be observed that both in Brazil and in the United States of America, since the creation of environmental statutes, there have been several cases, promoting intense debates about what would be the best way to apply environmental standards.

I. Environmental Law in Brazil

It is exceedingly difficult to write a history of Brazilian Environmental Law and not bring up Article 225 of the Federal Constitution of 1988, which established the fundamental right of all citizens to an ecologically balanced environment and determined that the Government must protect fauna and flora, under the terms of the law.

By the way, to complement the constitutional text, it should be noted that Law No. 6.938/91, which provides the National Environmental Policy, was decreed by Congress and sanctioned by the President of the Republic, only 03 (three) years later, defining in its article 2, the main object of the legal norm as follows:

> Article 2 - The National Environmental Policy aims at the preservation, improvement, and recovery of the environmental quality conducive to life, aiming to ensure, in the country, conditions for socio-economic development, the interests of national security and the protection of the dignity of human life, […].[6]

If that was not enough, the National Environmental Policy act defines the word “environment” as "the set of conditions, laws, influences, and interactions of a physical, chemical, and biological order, which allows, shelters, and governs life in all its forms;" (Art. 03, I).

In the meantime, CONAMA – National Council for the Environment, a consultative and deliberative body with the purpose of advising, studying, and proposing to the Council of Government guidelines for government policies for the environment, added to the definition of the legal term above, the "cultural and artificial heritage" in Resolution No. 306 of 07/05/2002, thus defining the environment as: “a set of conditions, laws, influences and interactions of a physical, chemical, biological, social, cultural and urban order, which allows, shelters and governs life in all its forms." [7]

After these premises, it is observed that the Federal Union is the main competent to regulate environmental protection in Brazil, and there is no general codification on the subject, or even a consolidation, consequently, there are numerous sparse statutes, as will be seen below.

It should also be noted that the development of environmental standards and regulations is concurrent

[5] ALDER, Robert W. *The Clean Water Act 20 years later*. Island Press. Washington, D.C. 1993. ISBN 1-55963-265-8. p. 13.

[6] BRAZIL, *National Environmental Policy*. Official Gazette of the Federative Republic of Brazil, Brasília, DF. Available: https://www.planalto.gov.br/ccivil_03/leis/l6938.htm. Access: Sept. 2023.

[7] BRAZIL, National Council for the Environment. *CONAMA Resolution: Resolutions in force published between September 1984 and January 2012*. Ministry of the Environment. Brasilia, 2012. p. 942 Available: https://conama.mma.gov.br/images/conteudo/CONAMA-ingles.pdf. Access: Sept. 2023.

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between the Union, States, and the Federal District (Art. 24, Federal Constitution)[8]. Therefore, it is up to the Federal Government to issue general rules, which will be detailed and specified by the States, Federal District and Municipalities, according to their local and regional interests.

Regarding the cultural environment, in addition to the Federal Constitution itself (articles 215, 216 and 216-A), there is, for example, Law 12.343/2010 (National Culture Plan) and Decree-Law 25/1937 (General Law of Heritage). In relation to the artificial environment, there is a constitutional provision in article 182[9], as well as Law 10.257/2001, called the City Statute.

In the field of natural environment (Article 225 of the Federal Constitution), the most fertile ground to produce regulations, such as: Law 5.197/67 (Protection of Fauna); Law 6.938/81 (National Environmental Policy); Law 9.433/97 (National Water Resources Policy); Law 11.284/2006 (Management of Public Forests); Law 12.651/2012 (Forest Code) etc.

The Forest Code determines that the protection and sustainable use of forests will take place through government action. The country, due to its vast territory and natural resources, has a complex political-normative system for the protection of the environment, led by the Federal Constitution of 1988, with competences attributed to public entities and agencies at all levels - federal, state, municipal and district.[10]

In this context, it is incumbent on all public entities – federal, state, and municipal – to protect the environment, as provided for in article 23 of the Federal Constitution. In other words, the Union, States, Federal District and Municipalities must coordinate reciprocally to achieve the constitutional objectives of protection and promotion of the environment, by the way, an indispensable resource for human beings, as well as comply with the laws enacted corresponding to each environmental subject, for example, legal instruments for the defense of fauna, water resources and even It also combats some types of animal abuse (cattle spree / bullfighting, fighting, etc.). [11]

In addition, the Judiciary itself, through its Superior Courts, the Supreme Court, and the Superior Court of Justice, have occupied a prominent position in the national scenario of Brazilian environmental law, thus also occurring in Brazil, the phenomenon of judicialization of environmental cases, such as the Forest Code, which will be dealt with in a separate topic due to its importance to Brazilian environmental law.

So, following the idea launched in the Declaration of the United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992 (Rio/92), there is a significant step forward in this phenomenon by saying that "the best way to deal with environmental issues is with the participation of all interested citizens, at various levels".

Principle No. 10 of Rio/92 seeks to make all information available to public authorities regarding the environment available to all interested citizens. In Brazil, this opening of popular access for the defense of the environment has as its main legal instrument, the Public Civil Action, which has as legitimized and can propose: Public Prosecutor's Office, Public Defender's Office, Union, States, Municipalities, Federal District and Associations Authorized by law.

Different to what happens with the North American class action system, the Brazilian legislator did not provide the possibility of assessing the so-called adequacy of representation, that is, that the judge verifies, in the specific case, whether the active legitimacy adequately represents the collectivity, category or class. In the Brazilian system, it is sufficient that the requirements required by law are met for representatives to be configured.[12]

Based on this facts, several lawsuits related to the environment are currently on the judicial court, such as the Direct Action of Unconstitutionality (ADI) 6148, which questions Resolution 491 of CONAMA – Council for the Environment on acceptable air quality standards and the Allegation of Non-Compliance with a Fundamental Precept (ADPF) 760, which deals with the resumption of the Action Plan for the Prevention and Control of Deforestation in the Amazon (PPCDAm), which reduced deforestation in the Amazon by 83% between 2002 and 2012.

Recently, in September 2023, the Superior Court of Justice, wich gives last word in relation to

[8] Art. 24. It is incumbent upon the Union, the States and the Federal District to legislate concurrently on: VI - forests, hunting, fishing, fauna, nature conservation, defense of soil and natural resources, protection of the environment and pollution control; VII - protection of historical, cultural, artistic, touristic and landscape heritage; VIII - liability for damage to the environment, to the consumer, to goods and rights of artistic, aesthetic, historical, touristic and landscape value;

[9] Art. 182. The urban development policy, implemented by the municipal government, according to general guidelines established by law, aims to order the full development of the city's social functions and ensure the well-being of its inhabitants.

[10] LEHFELD, Lucas de Souza. *Forest code commented and annotated* (article by article) / Lucas de Souza Lehfel d, Nathan Castelo Branco de Carvalho, Leonardo Isper Nassif Balbim. - Rio de Janeiro: Forense; São Paulo: MÉTODO, 2013. ISBN 978-85-309-4425-4. p. 36

[11] Art. 23. It is the common competence of the Union, the States, the Federal District and the Municipalities: [...] III – Protect documents, works and other assets of historical, artistic and cultural value, monuments, remarkable natural landscapes and archaeological sites; IV - Prevent the evasion, destruction and mischaracterization of works of art and other assets of historical, artistic or cultural value; V - To provide the means of access to culture, education and science; V - Provide the means of access to culture, education, science, technology, research and innovation; VI – Protect the environment and combat pollution in any of its forms; VII - Preserve forests, fauna and flora; XI - Register, monitor and supervise the concessions of rights for research and exploration of water and mineral resources in its territories;

[12] DANTAS, Marcelo Buzaglo Dantas. *Public Civil Action and the Environment.* Saraiva. 1 Edition. 2010.

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national statutes, issued Theme 1,159, in a decision of repetitive appeal, understanding "the validity of administrative fines for environmental infractions, provided for in Law No. 9,605/98, regardless of the prior application of the warning penalty."[13]. It should be noted that the Law in question provides for criminal and administrative repressive measures for non-compliance with environmental legislation and activities harmful to the environment.

According to the understanding set forth by the Superior Court of Justice in Topic 1,159, Law No. 9,605/98 did not establish any hierarchy among the administrative sanctions (warning, fines, seizure, etc.) provided for in article 72 for non-compliance with environmental legislation. In other words, according to the Superior Court cited, there is no legal provision in the environmental legal norm that conditions the application of a fine to the environmental offender, the need for prior imposition of the warning penalty.

It is noted that this phenomenon of judicialization of environmental causes has been gradually giving an intense protagonist to the Judiciary and making countries of the Civil Law tradition approach the Common Law, given the inability of the executive and legislative powers to keep up with the 'time' of hyper-complex societies, carrying out an evident gradual process of pairing primary sources of law between the law and judicial decisions.[14]

Thus, in Brazil, what some scholars call the Brazilian Hybrid System is being created, because the national legal system currently has as sources of Law techniques used both by the Common Law system, as well as by the Civil Law system, by the way, the latter still being preponderant in environmental matters, although, later, the laws are usually rectified or ratified by the Judiciary.

II. The Overview of the Brazilian Forest Code

The first Brazilian forest code was launched in 1934, during the government of Getúlio Vargas, along with the codes of Water, Mines and Hunting and Fishing. Subsequently, in 1965, then-President Humberto de Allencar Castello Branco sanctioned Federal Law No. 4,771, the outdated Forest Code, which established 50% of legal reserves in the Amazon and 20% in the rest of the country (Article 16) and defined the location of permanent preservation areas (Articles 2 and 3).

Currently, the last Forest Code was launched in 2012, and all of them seek to preserve the environment, especially permanent protection areas and legal reserves, which establishes general rules on how and where areas should be preserved, respecting their native vegetation, as well as which areas can be exploited in the national territory.

> Law No. 12,651/2012, which provides for the protection of native vegetation; amends Laws No. 6,938, of August 21, 1981, No. 9,393, of December 19, 1996, and No. 11,428, of December 22, 2006; repeals Laws No. 4,771, of September 15, 1965, in. 7,754, of April 14, 1989, and Provisional Measure No. 2,166-67, of August 24, 2001. This rule brought profound changes to the legal regime for the environmental protection of the Legal Reserve (RL), the Permanent Preservation Areas (APPs) and controversial innovations such as the regulation of the Rural Environmental Registry (CAR) and the Environmental Reserve Quota (CRA).[15]

Brazil enacted important legislation on the duty of environmental protection, known as the new Brazilian Forest Code, the third and most recent being launched by the Brazilian National Congress under Law No. 12,651/12 and the subsequent amendments through Law No. 12,727, of October 17, 2012, bringing new protective provisions and updating others that existed in previous laws in relation to environmental matters.

The Forest Code describes as permanent preservation areas (PPAs), the banks of rivers, watercourses, lakes, lagoons, and reservoirs, as well as hilltops and slopes with high slopes, covered or not by native vegetation, and such areas have the environmental function of preserving water resources, geological stability, biodiversity, fauna, and flora, thus protecting and ensuring the well-being of the entire population.

The Legal Reserve, on the other hand, is the area located inside the rural property that must be maintained with its original vegetation cover, with the function of ensuring the sustainable use of the area and protecting natural resources, as well as providing the conservation of biodiversity, combined with the protection of wild fauna and native flora. The areas that consist of the Legal Reserve vary according to the region where the rural property is located, and in the Amazon, it can reach 80% of the area and in the other regions of the country it is usually 20% to 30%.

Another crucial factor expressly introduced by the Forest Code, more precisely, provided for in its article 2, § 2, is the recognition of the *propter rem nature* of the obligation of environmental reparation in relation to environmental damage. The Superior Court of Justice, the court responsible for giving unity to infra-

[13] BRASIL, *Qualified Precedents, Theme 1159 of the Superior Court of Justice*. Available: https://processo.stj.jus.br/repetitivos/temas_repetitivos/pesquisa.jsp?novaConsulta=true&tipo_pesquisa=T&cod_tema_inicial=1159&cod_tema_final=1159 Access: Sept, 2023

[14] BODNAR, Zenildo. CRUZ, Paulo Márcio. *The commolization of positive law, judicial activism, and the crisis of the State.* New Legal Studies; Vol. 21, N. 3, 2016, p. 1343

[15] BENJAMIN, Antônio Herman Vasconcelos e; FREITAS, Vladimir Passos de; SOARES JÚNIOR, Jarbas. *Comments on environmental rulings:* paradigms of the Federal Supreme Court. Belo Horizonte. Fórum, 2021. p. 290-1

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constitutional law, interpreting the provision, issued the statement of Precedent No. 623: "Environmental obligations have a propter rem nature, and it is admissible to collect them from the current owner or possessor and/or from the previous ones, at the choice of the creditor." [16]

In addition, five years ago, the Brazilian Supreme Court, through its Plenary, decided en bloc actions that questioned several points of the Forest Code and its consequent constitutionality, through the joint judgment of Direct Actions of Unconstitutionality (ADIs) 4901, 4902, 4903 and 4937 and the Declaratory Action of Constitutionality (ADC) 42.

> The STF, in the judgment of several unconstitutionality actions brought against provisions of the New Forest Code, gave a more lenient interpretation to the principle of prohibition of socio-environmental setbacks, by understanding that it is not appropriate to disqualify a certain legal rule as contrary to the constitutional command to defend the environment (CF, art. 225), or even under the generic and subjective label of "environmental setback", not fully considering the various nuances that permeate the decision-making process of the legislator, democratically invested with the function of appeasing conflicting interests by means of general and objective rules. [17]

In other words, with the current evolution of society, combined with technological and scientific advances, the new environmental statutes cannot bring a reduction or flexibility of the environmental protection already achieved, under penalty of violating the principles of non-retrogression, full reparation of environmental damage and legal certainty. It is important to continue the permanent studies and techniques of sustainable environmental promotion in our country, respecting the Federal Constitution and other environmental standards in force.

By way of illustration, it is mentioned that other countries in the world are also moving in the same direction in terms of environmental protection, creating modern environmental legislation, such as the forest codes of the Netherlands, the Scandinavian countries, Germany, Australia and the new sustainability protection frameworks that have been created by European countries in the form of green plans (Netherlands, Sweden and France) and as National Strategies of the United Kingdom, Germany, among others, Canada and the United States, which have created similar and protective environmental strategies.[18]

III. Environmental Law in the United States of America

As a preliminary point, it should be noted that the legal system concerning the formulation of U.S. environmental law was created and molded under three (3) important characteristics: 1) the continental size of the country and its great diversity; 2) the federal system has many member states; 3) the fact that there is a system of government based on the principle of separation of powers.

In this context, although there are also state and local laws, it was the American Federal Government itself that took the lead in environmental legislation, playing a large role in the development of natural resources and infrastructure through various forms of public construction and investment in the areas that belonged to it and had great landscape and economic importance.

By way of illustration, the Yellowstone National Park, located in the US states of Wyoming, Montana, and Idaho, was inaugurated on March 1, 1872, that is, 150 (one hundred and fifty) years ago, being considered the oldest national park in the world and a milestone in the history of protected areas around the planet.

The federal government was also responsible for enacting the National Environmental Policy Act of 1969 (NEPA), one of the first written statutes that established a broad and national framework to protect and develop the environment in a correct and organized way.

NEPA's basic policy is to ensure that all branches of the U.S. government give due consideration to the issue before taking any major federal action that significantly affects the environment, and that an environmental assessment procedure should be conducted for the management of public lands and resources.

The federal government also ensured that U.S. federal agencies could consider the environmental impacts of their actions and decisions. Therefore, the U.S. National Environmental Policy Act is an important, if not the most important, piece of legislation in U.S. environmental law.

Notwithstanding the above-mentioned important facts, the federal government has still carried out numerous regulations on pollution and industrial hazards to the detriment of the environment, beginning in 1970 with the Clean Air Act (CAA) and continuing since then with important statutes in the areas of Clean Water Act (CWA), control of toxic substances and toxic waste. In addition, the federal government has played a very important role in the regulation of nuclear energy, chemicals, the greenhouse effect and pesticides.

In 1990, Congress passed a significant revision to the Clean Air Act that overhauled certain key components of the Act (hazardous air pollutants), added

[16] BRAZIL, *STJ Precedents Review*. Digital Legal Library (BDJur) Available: https://www.stj.jus.br/publicacaoinstitucional/index.php/sumstj/article/viewFile/5052/5179. Access: Sept, 2023.

[17] BENJAMIN, Antônio Herman Vasconcelos e; FREITAS, Vladimir Passos de; SOARES JÚNIOR, Jarbas. *Comments on environmental rulings:* paradigms of the Federal Supreme Court. Belo Horizonte. Fórum, 2021. p. 472

[18] BOSSELMANN, Klaus. *The Principle of Sustainability: transforming law and governance.* Farnham: Ashgate, 2008. P. 107.

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new programs (acid rain title, Title V operating permit program, and the stratospheric ozone program), and continued to build upon the existing structure that was put in place by the 1970.[19]

Although all the above goals are laudable and ambitious, the implementation process has been slow and complicated since there is great diversity in the nation and in the 50 (fifty) American states that represent the federal structure of the country.

Therefore, beginning with the Clean Air Act (CAA), U.S. Congress enacted "citizen process" clauses in at least twenty (20) environmental statutes, as it was recognized by the Senate Committee on Environment and Public Works that citizens played an influential role in the enforcement activity against violators of environmental laws.

These provisions serve to fulfil two distinct and significant functions. They authorize "any person" to bring a civil action (1) against any person who is "alleged to have violated" a standard, limitation, or permission under the statute or (2) against the Environmental Protection Agency (EPA) Administrator for failure to perform a non-discretionary duty under the law.

Thus, environmental regulations have often begun to be challenged in the courts, providing an influential role for the courts and litigants, as they are open not only to the regulated industry, but also to environmental groups and others who have environmental claims.

Lawsuits by U.S. citizens over the past thirty-five (35) years have had an enormous impact on improving government compliance with environmental law and encouraging government agencies to implement those laws in creative and expansive ways. In other words, American society, through its citizens, had a new expanded role in the governance of the environment.

The use of litigation by environmentalists has once again become daily, for instead of seeking a comprehensive transformation of the law, if in passing, slow and time-consuming, environmentalists increasingly began to return to the courts for real and maintain legislative victories that they had conquered in the past. [20]

These legal disputes in the U.S. judiciary have produced important and symbolic victories. For example, in Citizens Can Preserve Overton Park, Inc. v. Volpe - 401 US 402 (1971) - when a major reinterpretation of the rules of judicial review took place to give significant protection against environmental threats to the disappeared "green havens". The case also marked the beginning of public interest litigation on environmental issues.

Another historic victory for environmentalists was Massachusetts v. EPA, 549 US 497 (2007), when it defended the urgency and priority of action on climate change and concluded that greenhouse gases are air pollutants under the Clean Air Act and can be regulated by the US Environmental Protection Agency (EPA).[21]

Not to mention the emblematic case of Chevron-Ecuador when the oil company lost a historic trial and was ordered to pay compensation of 9.5 billion dollars to farmers and Indigenous people in the South American region for allowing and/or polluting the Ecuadorian Amazon region.

Over the past four decades, “Environmental Law” has evolved into a legal system of statutes, regulations, guidelines, requirements, policies, and case-specific judicial and administrative interpretations that address a wide-ranging set of environmental issues and concerns. These laws and requirements address not only the natural environmental, including the air, water, and land, but also how humans interact with that natural environmental and ecological system.[22]

Therefore, both in the United States of America and in the world itself, the creation of normative sources of International Law and Environmental Law itself must result from Society as a whole and, cumulatively, from the capacity of its Institutions to exercise the authority they possess, strengthening the structuring foundations of the environmental legal system and consequently nature itself.

IV. Final Consideration

It is concluded that countries such as North America, traditionally known as coming from the legal system called Common Law, possess, and use as much force of law from the Legislative and Executive Branches, as a typically European or Latin American country, which are widely known as countries coming from Civil Law.

In other words, some nations that do not have the jurisdiction of Civil Law, have more codes and statutes than countries of this family and, currently, Latin American countries, for example, Brazil, have gradually increased the use of Common Law instruments through the strengthening of judicial decisions and their binding effects, including in the environmental field.

[19] BELDEN, Roy S. MORRISON, Angela R. *Clean Air Act: essential.* American Bar Association. Section of environmental, Energy, and Resources, sponsoring body. Third Edition, Chicago, Illinois, 2021. p. 09

[20] CANNON, Jonathan Z. *Environment in Balance: The Green Movement and the Supreme Court.* Cambridge/MT: Harvard University Press, 2015.

[21] LAZARUS, Richard J., *The rule of five:* making climate history at the supreme court. Cambridge, Massachusetts: The Belknap Press of Harvard University Press, 2020.

[22] SULLIVAN, Thomas F. P. *Environmental Law HandBook 23rd Edition.* Bernan Press, Maryland. 2017. ISBN 978-59888-865-2. p. 01

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This happens because the ultra-complex societies of modernity increasingly require quick answers and solutions that the Legislative Branch cannot demand in the necessary time, thus serving the Judiciary as an important legislator through its binding decisions (Precedents, Statements, Repetitive Appeals and Precedents).

In the field of Environmental Law itself, it is observed that International Environmental Law had a profound influence both in Brazil (the country where one of the most important world summits on the environment was held) and in the United States of America (one of the world's largest powers).

So, both countries have federal environmental legislation that guides the entire structure of the domestic Environmental Law of each country, with constant updating through Laws and Regulations created by the Executive and Legislative Branches, as well as Judicial Decisions issued by the Judiciary.

Therefore, the United States of America increasingly uses legal norms to strengthen the protection of the environment, without losing sight of the use of the instrument called judicial review, which is practiced by the Judiciary in the United States in relation to Laws and Regulations that may be declared unconstitutional (Marbury v. Madison) by reason of the Common Law tradition.

Brazil, on the other hand, has been gradually introducing new concepts and instruments from the Common Law system, such as Judicial Precedents, Repetitive Appeals with binding effect, etc., although it remains a nation traditionally based on Civil Law, where the authority of the national legislation is still – or should be – superior to judicial decisions.

In this way, both countries began to incorporate satisfactory results in their domestic scenario and should maintain a long participatory path of all sectors/social actors in the search for environmental protection, under the principles of sustainability, aiming at the use of the current and future generation.

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The Quantum Mechanism of Earthquakes as Exemplified by a Sudden Ejection of Rocks from a Rock Mass

By Serguei Bytchkov

Abstract- At the moment, there are several hypotheses in geophysics that explain especially dangerous processes of the earth's crust movements - sudden outbursts of rocks and gas from a rock mass from the point of view of classical physics. Despite the fact that various macroscopic systems can be accurately described using classical mechanics and electrodynamics, a real mechanism and a working model of this phenomenon cannot be built. Consequently, to develop a model of sudden outbursts of rocks and gas, it is necessary to apply new approaches and methods, different from the description of macroscopic systems. This article describes a quantum version of the process of the ejection of rocks from a rock mass. In particular, we described the mechanism of the Coulomb explosion that occurs in the rocks of the earth's crust with a sharp change in rock pressure and built a model of the sudden release of rocks and gases. In our opinion, the quantum processes described by us can be sources not only of sudden outbursts and rockslide but also sources of more formidable phenomena - earthquakes and volcanic explosions.

Keywords: *quantum, photon, electron, earthquake, chemical chain reaction (CCR).*

GJHSS-B Classification: *FOR: 0404*

THEQUANTUMMECHANISMOFEARTHQUAKESASEXEMPLIFIEDBYASUDDENEJECTIONOFROCKSFROMAROCKMASS

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The Quantum Mechanism of Earthquakes as Exemplified by a Sudden Ejection of Rocks from a Rock Mass

Serguei Bytchkov

Abstract- At the moment, there are several hypotheses in geophysics that explain especially dangerous processes of the earth's crust movements - sudden outbursts of rocks and gas from a rock mass from the point of view of classical physics. Despite the fact that various macroscopic systems can be accurately described using classical mechanics and electrodynamics, a real mechanism and a working model of this phenomenon cannot be built. Consequently, to develop a model of sudden outbursts of rocks and gas, it is necessary to apply new approaches and methods, different from the description of macroscopic systems. This article describes a quantum version of the process of the ejection of rocks from a rock mass. In particular, we described the mechanism of the Coulomb explosion that occurs in the rocks of the earth's crust with a sharp change in rock pressure and built a model of the sudden release of rocks and gases. In our opinion, the quantum processes described by us can be sources not only of sudden outbursts and rockslide but also sources of more formidable phenomena - earthquakes and volcanic explosions. The article describes a completely new approach to geophysical processes in the earth's crust, based not on elastic forces, but on quantum processes between atomic particles of rocks participating in the processes of emissions of earthquakes, volcanic explosions.

Keywords: quantum, photon, electron, earthquake, chemical chain reaction (CCR).

I. Introduction

It is known that depending on the type of atomic particles located in the nodes of the crystal lattices, and the nature of the bond between the particles, there are four types of lattices: ionic, atomic, molecular, and metallic. It is known that the rocks of the earth's crust contain almost no pure substances, i.e. Rocks are a composite of many elements, which means that any rock can contain an ensemble of various types of crystal lattices, randomly located throughout the volume of rocks in the form of mineral inclusions. It is known that the crystal lattice can explode due to the destruction of bonds between atomic particles in accordance with the mechanism of the Coulomb explosion, which consists in the fact that between the atomic particles located in the nodes of the crystal lattice there are Coulomb repulsive forces, which are compensated by the electrons in the volume of the lattice. It is known that in the case of the removal of a part of electrons from the lattice volume, the Coulomb destruction of bonds between the particles occurs and the crystal lattices instantly explode with the release of energy. It is known that the process of a Coulomb explosion takes $\geq 10^{-9}$ s. Consider the classic examples of the Coulomb explosion described in the scientific literature. *Chemical Coulomb explosion.* Until now, the scientific world knew and firmly believed that the explosion of sodium in water occurs due to its active reaction with water, during which a large amount of heat and molecular hydrogen $2Na + 2H_2O = 2NaOH + H_2 \uparrow$ is released, which leads to the formation and explosion oxyhydrogen gas $2H_2 + O_2 = 2H_2O$. And suddenly, in 2015, a group of Czech scientists discovered that this was not true! As scientists have shown during experiments [1] recorded on a high-speed camera, when sodium is immersed in water, there is an immediate exit of electrons from the metal surface. As a result of the process, an electron deficiency arises in the lattices of sodium molecules. As a result, the Coulomb repulsive forces of ions begin to prevail, which leads to the explosion of the lattice with the release of the explosion energy. *Mechanical Coulomb explosion*. In this type of Coulomb explosion, the atoms-ions of the nodes of the crystal lattice are bound by free electrons, which move inside it in a random manner, reminiscent of the movement of an electron gas. It was shown in [2, 3] that if free electrons are “distracted” from the role of “glue” by increasing the energy of the electron flow, this will lead to the escape of electrons from the crystal lattice and its explosion. The increase in the energy of the electron flow can be achieved in several ways: 1. Due to the inertial forces of electrons. A striking example of such a case is the sharp deceleration of a modern high-speed projectile when it hits the armor of a tank and the appearance at this moment of the inertial force of electrons, which continue to move and, due to the inertial forces that have arisen, fly out of the crystal lattice. A Coulomb projectile explosion occurs, the energy of which burns through the tank's armor. The fact that the inertial process of the Coulomb explosion is real was shown by the famous experiment with a coil of copper wire conducted by the American scientists Tolman and Stewart (Tolman R. C., Stewart T. D.) back in 1916. 2. Due to the forces of electromagnetic nature, when a high-density electric current is passed through a substance or irradiated with a high energy laser beam. It is known that the current density is proportional to the

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electron flow velocity, and the kinetic energy is proportional to the square of the velocity. Consequently, if the current density is increased by a factor of a thousand, the kinetic energy of the electron flow will increase by a factor of one million and they will unanimously leave the crystal lattice, which will naturally lead to a Coulomb explosion. At the moment, there are several patents for "Method of the explosion of solid metal using electrical force," for example, RU2145147C1 [4].

II. Theoretical Part

Below we give examples of sudden outbursts of rocks and gas from a rock mass from which it can be concluded that nature uses both chemical and mechanical, and combined mechanisms of the Coulomb explosion in the processes of emissions. A common feature of Coulomb explosions is the release of a by-product - a large amount of ultrafine dust, the so-called rabid flour (up to 40% of the total mass of the ejection), with particle sizes within a few nanometers, which can be formed during the ejection of rocks and gas only in a single case - as a result of the destruction of crystal lattices [5], because such a fine grinding of the rock cannot be achieved by any kind of blasting or without special equipment. The formation of a gaseous phase during the processes of sudden outbursts of rocks is also a by-product of the process, which makes an additional contribution to the energy characteristic of the Coulomb explosion. The gaseous phase is formed for two reasons: 1. In chemical reactions of the type of formation of hydrogen molecules during the reaction of sodium in water. For example, due to hydroxide ions in the crystal lattices of hydroxides and basic salts. 2. As a result of dissociation and ionization of molecules of a solid solution of gases formed in the crystal lattices of rocks at the moment of formation of the rock mass and passing into a free state in the focus of the Coulomb explosion due to the emerging chemical chain reaction (CCR). The chain nature of the reaction is caused by the appearance of accelerated electrons, which are not only the source of the Coulomb explosion but also the initiator of the CCR and which in turn will cause the appearance of intermediate active particles (free radicals, excited atoms, and molecules) [6, 7, 8]. It should be noted that the formation of the gaseous phase and the passage of the shock wave of the Coulomb explosion cause another physical phenomenon in the rock mass, which is especially pronounced during underground emissions - the Richtmyer - Meshkov instability [9], which results in a sudden outflow of turbulent gas jets from the rock mass and the destroyed particles of rocks captured by them from the point of origin of the disturbance following the front of the shock wave.

III. Quantum Rock and Gas Ejection Mechanism

During the formation of an elementary rock mass, as a result of the action of high temperatures, pressure, an aggressive environment, and the stresses arising from the movement of rock blocks, metamorphic transformations of the mass occur. Over time, the rock massifs not only change the geological, geometric, and chemical form and structure, but also energy parameters. As a result of the compaction of rocks (a change in its volume), as well as from the effect of high temperatures, energy in the form of quanta is imparted to the electrons of the rocks. According to Mr. Bohr's quant model of the atom, if the energy imparted to the electron exceeds the critical potential, then the electron goes to a higher level, storing potential energy (a macroscopic analogy is a compressed spring). A mountain range in such a metastable state can remain indefinitely. Over the years, at a random moment in time, as a result of the confluence of various natural or man-made factors, there is a sharp decrease in rock pressure in the considered elementary volume of the rock mass. In this case, the rock mass changes its volume and shape in the form of rock heaving (analogy - the spring is unclenched) and as a result, its potential energy sharply decreases, and the kinetic energy, and therefore the speed of electrons, atoms, and molecules, increases sharply, which leads to their mutual inelastic collision of the second kind, the appearance of electric charges and the appearance of an electromagnetic field. In this process, it is especially important that in inelastic collisions of the second kind, electrons do not emit quanta, but on the contrary, energy is transferred from excited atoms and molecules to electrons. As a result, electrons are accelerated and leave the crystal lattice, simultaneously initiating two processes - the Coulomb explosion and the CCR. There are two things to note here. 1. The first nuance is associated with the behavior of hydrated water molecules. In the generated electromagnetic field, the H_2O molecules create a hydration shell around the ions of the crystal lattice, which screens the ions from charges of the opposite sign. And since water, depending on the temperature, has a high dielectric constant of $\sim$ 80, the electrostatic attraction of ions and electrons will accordingly decrease $\sim$ 80 times. It should be noted that many rocks of the lithosphere contain hydroxide mineral impurities containing hydrated water: [(SiO_2, Al_2O_3, TiO_2, Fe_2O_3, CaO, MgO, K_2O, Na_2O) • nH_2O]. For example, the mineral constituent of marble limonite - Fe_2O_3 • nH_2O, is also the mineral constituent of coal and many other rocks. In connection with the leading role of the dielectric constant in the ejection processes, it should be noted the class of so-called ferroelectrics, which can also be part of rocks, for example, the constant of the dielectric constant of tetrahydrate of double sodium-

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potassium salt $KNaC_4H_4O_6$ $4H_2O$ is much higher than water and is ~ 500. 2. The second nuance lies in the fact that the nucleation of chains occurs with the participation of numerous admixtures-initiators, which are rich in rocks. Such impurities can be molecules with a weak bond, for example, alkali metals, during the decomposition of which free radicals are easily formed, or molecules that easily enter into redox reactions. For example, coal ash, depending on the grade, contains: 1.3 - 80.9% Fe_2O_3; 0.87 - 42.7% Al_2O_3; 1.7 - 76% SiO_2; 0.6 - 36.9% CaO; 0 - 10.7% SO_3. In addition, small amounts of lithium, potassium, sodium, magnesium, rubidium, cesium, sulfur, phosphorus, sometimes titanium, zinc, copper, nickel, etc. are included in the composition of coal, which can act as initiators of the CCR. Consider a few examples of sudden rock and gas outbursts.

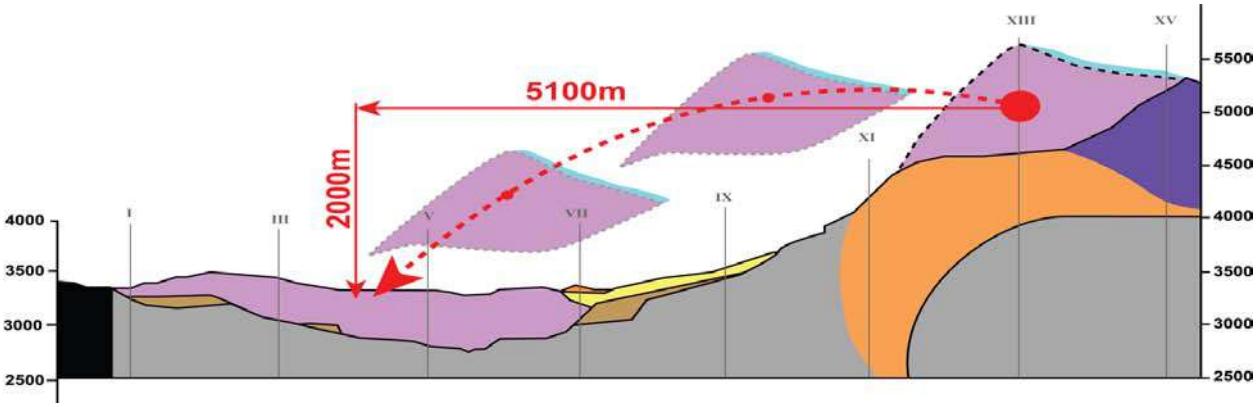

Fig. 1: Usoy landslide [10] page 280

The Usoi collapse [10] that occurred in the Pamirs on 02/18/1911., Fig. 1, can be considered a sudden release of rocks and gas, because a block of rock with a volume of ~ 1.5 km^3, after being torn away from the parent body, did not just slide down the slope, but flew a distance of 5 km. along an inclined path. The calculated energy and momentum of force for the movement of a physical body of such a mass is 1.1×10^{17} J. To date, there is no reasonable explanation for this well-described and documented case in the scientific literature, however, as well as other similar catastrophic collapses. We believe that the Usoi collapse occurred due to the Coulomb explosion that occurred at the time of a sharp change in the cantilever loads in the mother's body when various natural mining-hydro-geological and weather factors coincided in time. It is known that the displaced mass of the ejection consisted of siliceous shale, and the bed of the ejection funnel was lined with reddish marble. According to our hypothesis, as a result of a combination of various factors, the cantilever loads exceeded the ultimate strength of the rocks in the zone of contact between siliceous shale and marble. A sudden redistribution of loads led to the appearance of accelerated electrons in the array, which, having received energy from excited atoms and molecules and the energy of inertial forces at the moment of acceleration, were forced to leave the crystal lattice. The electromagnetic field induced by the moving stream of electrons unfolded the dipoles of the hydrated water of the marble, which isolated the ions of the crystal lattice and compensated for the Coulomb forces of attraction between the ions and electrons by the value of the constant of dielectric permeability, which gave rise to the reactions of the Coulomb explosion and CCR. The resulting impulse of force with an energy of $1.1 \bullet 10^{17}$ J. threw a part of the mountain range with a volume of 1.5 km^3 at a distance of 5 km. The resulting gases scattered in the atmosphere. The collapse zone was covered with a layer of rabid flour, the deposits of which can be traced to the present day. In addition, the researchers found melted pieces of rocks, which in no way fit into the gravitational hypothesis of collapse. Our hypothesis assumes that the fused rocks serve as strong evidence of the high-speed process of the Coulomb explosion that occurred, accompanied by the release of a significant level of thermal energy, which the massif did not have time to take away and that served as an impetus for further heating of rocks and gases in geometric progression and for the even greater acceleration of reactions due to shock ionization. A month ago, a similar incident occurred in the vicinity of Toronto, Canada, and was accompanied by the sound of a strong explosion and a thick cloud of rabid flour [11]. True, the caliber of this emission was much smaller.

IV. Sudden Rock and Gas Outbursts in Underground Potash and Coal Mines

From the experience of underground mines for the extraction of potash salts and coal, it can be concluded that the amount of rock and gas emissions increases with the depth of mining, that is, with an increase in rock pressure. Let us give an example of a classic discharge that occurred on June 7, 1953, at the

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Menzengraben mine (Germany). At the time of the release, several hundred thousand cubic meters of gas were released and about 100,000 tons of salt were emitted. The gas mixture consisted of CO_2 (up to 95%) and N_2. Gas escaped noisily from both shaft shafts 520 m deep for about 25 minutes. The blowout completely disrupted ventilation, destroyed the mining equipment, the reinforced concrete roof of the mine shaft [12]. Based on the consideration of the conditions of the Coulomb explosion, we can conclude that the mined potassium salt - carnallite $KCl \bullet MgCl_2 \bullet 6H_2O$, ideally meets the requirements of the initiator of the Coulomb explosion and CCR. Carnallite is an aqueous potassium chloride, which is no less aggressive metal than sodium, which has hydrated water molecules in its composition. In addition, the mineral carnallite includes impurities of other, no less aggressive alkali metals - rubidium and cesium, which, in turn, can act not only as initiators of the Coulomb explosion but also as catalysts for CCR. And the last, no less important point, a sudden release occurred at the time of blasting, that is, at the time of a sharp drop in rock pressure in the massif. In this case, an ideal case of a merger of chemical and physical and mechanical factors occurred, which led to a powerful ejection of rocks from the massif, which ended in a gas ejection as a result of the Richtmyer-Meshkov instability. According to the same scheme, sudden rock and gas outbursts occur in coal mines, but since coal contains much less alkali metal impurities in its composition, the process of coal sudden rock and gas outbursts is extended over time. Initially, several local mini-Coulomb explosions occur, which accompany the CCR of insignificant strength. In the process of "swinging," more and more atoms and electrons are drawn into the ejection process. In the rock mass, noise effects, increased gas release, firing of the rock with pieces of coal, peeling of the face and sides of the mine start, and only after such “swinging” a full-fledged release of rocks and gas occurs. Although, sudden rock and gas outbursts of significant strength can occur immediately, without “swinging.” With the largest emissions, millions of m^3 of gas were released and emitted tens of thousands of tons of coal.

V. Conclusion

The ordinariness of the process of the Coulomb explosion, convincingly demonstrated in the reaction of sodium in water, destroyed the myth of the Coulomb explosion as a process capable of proceeding only at high energy costs and parameters, at high P, T and only in special cases, supposedly unattainable under normal conditions of existence of matter ... Based on the above examples, we have shown the possibility of a Coulomb explosion in the rocks of the earth's crust. Moreover, we argue that earthquakes and volcanic explosions occur according to the same scenario since the rocks of tectonic plates - granites and basalts contain oxides and mineral admixtures of alkali metals, hydrated water, and high variable loads of tectonic plates at high temperatures of rocks contribute to entrainment of large volumes of material into the process, which leads to the release of huge amounts of seismic energy

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The Relationship between basic Sanitation and Awareness in the Velho Dam

By Jadyni Ester Matos e Silva

Abstract- This article aims to describe the damage caused to the population and the environment with the dumping of untreated effluents in the Old Dam located in the municipality of Salgueiro - PE, considering the possible diseases that can cause for the residents and the damage to aquatic animal life. Within this context, this work proposes to present the methodology of basic research and field research in the study area of the dam, emphasizing the inhabitants' perceptions about the characteristics of the studied area due to the lack of sanitation.

Keywords: *weir, sanitation, search, illness, Salgueiro-PE.*

GJHSS-B Classification: *LCC: TD420-428*



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The Relationship between basic Sanitation and Awareness in the Velho Dam

As Relações Entre Saneamento básico e Conscientização no Açude Velho

Jadyni Ester Matos e Silva

Resumo- O presente artigo tem como objetivo descrever os danos causados a população e ao meio ambiente com o despejo de efluentes não tratados no Açude Velho localizado no município de Salgueiro – PE, fazendo considerações sobre as possíveis doenças que podem acarretar para os moradores e os prejuízos para vida animal aquática. Dentro desse contexto, este trabalho propõe-se apresentar a metodologia de pesquisa básica e pesquisa de campo na área de estudo do açude, enfatizando as percepções dos habitantes acerca das características da área estudada por conta da falta de saneamento. Com os estudos foi possível apontar que a falta de saneamento é a principal causa para o aumento de mosquitos, certas doenças e mal cheiro nos arredores.

Palavras-chave: açude; saneamento; pesquisa; doença; Salgueiro-PE.

Abstract- This article aims to describe the damage caused to the population and the environment with the dumping of untreated effluents in the Old Dam located in the municipality of Salgueiro - PE, considering the possible diseases that can cause for the residents and the damage to aquatic animal life. Within this context, this work proposes to present the methodology of basic research and field research in the study area of the dam, emphasizing the inhabitants' perceptions about the characteristics of the studied area due to the lack of sanitation.

Keywords: weir; sanitation, search, illness, Salgueiro-PE.

I. Introdução

Os açudes são um dos principais recursos usados no combate às secas do Nordeste brasileiro, servem para abastecimento, para irrigação e outros fins. A região nordestina é a que mais detém em número de açudes no Brasil, e o principal responsável é o órgão DNOCS que é uma autarquia federal que possui vínculo com o Ministério de Desenvolvimento Regional, atua no Nordeste brasileiro desde 1909 e tem como base em sua legislação executar políticas do governo federal no que diz respeito a beneficiamento de áreas e obras de proteção contra as secas e inundações, irrigação, radicação da população em comunidades de irrigantes e subsidiariamente outros assun tos que lhe sejam cometidos pelo Governo Federal, nos campos do saneamento básico, assistência às populações atingidas por calamidades públicas e cooperação com os Municípios.

A criação de um açude detém várias finalidades, mas com o passar do tempo podem não ter mais essa funcionalidade, a exemplo, um açude de início foi criado para abastecer uma comunidade ou uma região, mas com o crescimento da cidade outras redes de abastecimento foram criadas e o açude perde essa função principal, mas não deixa de ter criado um "ecossistema" local e toda uma funcionalidade em torno da área. Mas com o crescimento das cidades um problema bem recorrente surge que é o tratamento de esgotos e como isso se relaciona a açudes?

Uma das "soluções" adotadas por uma grande parte das cidades é despejar os efluentes tratados ou não em açudes, rios ou lagos das regiões. Mas o principal ponto do despejo de efluentes é quando não é tratado e jogado diretamente nos corpos d'água, tem muitas consequências negativas em relação a doenças para a população, mal cheiro, mosquitos, lixo que também se acumula nas margens, e consequências negativas para as plantas e vida aquática da localidade. E esse caso é o do Açude Velho localizado no município de Salgueiro – PE que recebe o despejo de efluentes não tratados no corpo d'água.

Com base nessa contextualização argumenta-se: Como o despejo de efluentes não tratados no Açude Velho impacta socioambientalmente a população de Salgueiro PE?

O objetivo central do artigo foi descrever os danos causados a população e ao meio ambiente com o despejo de efluentes não tratados no Açude Velho localizado no município de Salgueiro – PE.

Esse trabalho segue estruturado por meio dessa introdução onde é apresentada a problemática e relevância do tema, os objetivos. Na segunda parte o referencial teórico, onde se discute os temas da criação e os tipos de açudes, sobre saneamento básico, o conceito e a situação atual no Brasil e também o comprometimento da água a respeito de poluição. A próxima parte é a metodologia utilizada. E por fim a análise dos resultados obtidos e discussão dos resultados, considerações finais e relevância do estudo.

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II. Utilização de Açudes

Abastecimento agrícola, residencial, produção de energia elétrica, defesa contra cheias de rios e regularização de um caudal, são algumas das finalidades para a construção de um açude.

A forma de construção varia de acordo com o material usado e com a localidade podendo ter na sua composição concreto, areia, terra e outros tipos de materiais. Os açudes são um recurso muito antigo que vem desde o início da civilização para combater as secas, esse recurso ainda é largamente utilizado no Nordeste brasileiro por conta dos longos anos de seca nas décadas passadas, em principal a de 1915 que é descrito como "A Grande Seca" por diversos autores. Nesse contexto o Nordeste é a região que detém a maior rede de açudes do Brasil (RIBEIRO 2010).

O órgão que tem maior responsabilidade pela construção de açudes é o Departamento Nacional de Obras contra as Secas (DNOCS) que tem atuação no Nordeste desde 1909 e consta na sua legislação básica:

> Executar políticas do governo federal no que diz respeito a beneficiamento de áreas e obras de proteção contra as secas e inundações e subsidiariamente outros assuntos que lhe sejam cometidos pelo Governo Federal, nos campos do saneamento básico, assistência às populações atingidas por calamidades públicas e cooperação com os Municípios, possuindo grande atuação no semiárido do Nordeste e norte de Minas Gerais.

Dentro da regularização do DNOCS uma das políticas mais executadas é a construção de açudes, como descrito anteriormente, o mesmo foi responsável pela implementação de mais de 300 açudes públicos de médio e grande porte em toda a região semiárida brasileira. Entre as maiores obras de engenharia do órgão, incluem-se os açudes públicos do Orós e do Castanhão, ambos no Estado do Ceará, e o do Açu, no Rio Grande do Norte, todos com capacidade de armazenamento superior a 1 bilhão de metros cúbicos.

III. Saneamento e a Situação do Brasil

O saneamento básico tem como pilares: a distribuição de água potável, coleta e tratamento de esgotos, drenagem urbana e coleta de resíduos sólidos. Os serviços impactam diretamente na saúde, qualidade de vida e no desenvolvimento da sociedade com um todo.

No Brasil, o saneamento básico é um direito assegurado pela Constituição e definido pela Lei nº. 11.445/2007. Mas a discrepância dos tramites da lei para a realidade brasileira é alarmante ainda são mais de 35 milhões de pessoas sem acesso à água potável. Um número contraditório para um país tão rico em recursos hídricos. O baixo investimento em saneamento leva a população a criar meios locais para ter acesso a água, prática que nem sempre é saudável.

Quanto maior o acesso ao saneamento, menor a mortalidade infantil, menor a taxa de internações por doenças gastrointestinais e maior a longevidade da população. O saneamento precário cria o ambiente propício a muitas doenças, inclusive as transmitidas pelo mosquito Aedes aegypti. Elas são causadas pela ingestão de água contaminada ou pelo contato da pele ou mucosas com a própria água, lixo ou solo infectados.

Para Kronemberger (2018) a relação entre saúde e saneamento é seus impactos nos 100 maiores municípios do Brasil entre 2008 e 2011, concluiu-se que em 2010, os baixos índices de coleta de esgotos foram acompanhados por altas taxas de internação por diarreias em 60 de um total de 100 cidades pesquisadas. Entre as 20 cidades com menor taxa de internação, em média, 78% de população é atendida por coleta de esgotos.

Segundo definição da norma brasileira NBR 9648 (ABNT, 1986): "Um esgoto consiste na água que se é descartada dos banhos, limpeza de roupa, louças e descargas do vaso sanitário."

Os resíduos oriundos das residências constituem os esgotos domésticos, os que são formados no processo de fábricas recebem o nome de esgotos industriais e as água das chuvas são identificados como pluviais e não podem ser lançados na rede de esgoto. Esta separação é crucial porque para cada tipo ocorre formação de substâncias diferentes e necessidades de sistemas específicos para afastar e tratar os resíduos.

Em geral o esgoto não tratado traz numerosos agentes patogênicos, microrganismos, resíduos tóxicos e nutrientes que geram o crescimento de outros tipos de bactérias, vírus ou fungos presentes em menor número. Por esta razão, os sistemas de coleta e tratamento de esgotos são determinantes para a saúde pública, ao evitar riscos de contaminação e transmissão de doenças; e ao meio ambiente no que se refere ao controle da poluição das águas.

No Brasil, a operação dos serviços de coleta de esgoto pode ser feita por empresas públicas ou privadas, em regime de concessão, parceria público-privada, subdelegação, etc. No entanto, dados do Trata Brasil (2018) mostram que a coleta de esgoto no país atualmente é pouca coisa superior a 50%. Isso significa que quase metade do país não tem acesso nem ao serviço de coleta. Todo o restante não tratado, ou mesmo não coletado, é lançado in natura nos corpos hídricos disponíveis, afetando diretamente a saúde pública e o meio ambiente.

IV. Poluição da Água

Existem diversas formas dos corpos d'água serem poluídos e afetarem o comprometimento do mesmo. As atividades humanas são os principais meios

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de poluição, como o descarte errado de produtos e o lançamento de esgoto e produtos químicos na água.

Para Leite (2019) O lançamento de compostos inorgânicos nos lagos, rios e mares feito pelas indústrias, como ácidos, bases e sais, alguns que oferecem maiores perigos são os compostos de metais pesados (Cu, Zn, Pb, Cd, Hg etc.). A falta de saneamento básico tem uma parcela significativa para a poluição da água e quando despejado diretamente no corpo d'água pode causar diversas alterações negativas para a vida humana e aquática. As principais doenças associadas ao consumo de água contaminada são as infecções gastrointestinais, disenteria, leptospirose, cólera e hepatite.

V. Metodologia

Foi utilizado o método de pesquisa básica com a finalidade de obter novos conhecimentos para avanço social através de um estudo bibliográfico composto por artigos científicos e sites público. O objetivo central do trabalho é trazer conhecimento geral sobre saneamento básico e sua implicação direta no Açude Velho localizado no município de Salgueiro – PE.

Em dez de setembro de 2021 foi feito uma primeira visita de campo no Açude Velho para coleta de imagens do estado atual, e no final do mês de outubro de 2021 foi realizada uma segunda visita para servir de comparação de quando o açude recebe limpeza da prefeitura municipal. Uma pesquisa bibliográfica sobre a situação do açude nos últimos anos foi realizada consultando sites da prefeitura municipal e blogs da cidade. Quando consultado o site da prefeitura de Salgueiro vê-se várias matérias constando a limpeza do açude como dito anteriormente, pois com esse esgoto sendo jogado cresce uma espécie de planta que cobre a água inteira, os Aguapé.

Com essas informações foi possível identificar as consequências que essa situação provoca para a população que habita na localidade e para o ecossistema do ambiente. Para atestar os pontos mais evidentes das consequências do despejo no Açude Velho, foi realizado a criação de um questionário contendo cinco questões com as opções de respostas: Sim, Não e Não sei informar, esse questionário foi aplicado para cinco moradores que residem no bairro Divino Espírito Santo onde fica localizado o açude. Os dados do questionário foram analisados de forma quantitativa usando as porcentagens das respostas como parâmetro para a realidade.

Para uma compreensão dos riscos que a falta de saneamento pode trazer para a saúde pública foi realizada uma entrevista com um técnica de enfermagem que atua no Hospital em Salgueiro há mais de 20 anos, lhe foi questionado quais os tipos de doenças que podem ocorrer com a falta de saneamento básico e qual era a frequência que algum caso desse surgia no hospital e se algum tinha relação direta com o açude ou não. As respostas foram analisadas e constando somente o foco central do tema.

VI. Resultados e Discussões

Na pesquisa de campo foram apresentadas as condições do Açude Velho na data 10/09/2021 com sua água poluída pelo esgoto e pelo lixo que é despejado pela população. Logo abaixo está disposto na figura 1 as imagens que foram selecionadas.



Imagem 1



Imagem 2

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Imagem 3



Imagem 4



Imagem 5



Imagem 6

Fonte: Google imagens/Autor

Figura 1: Açude Velho antes da limpeza

Na imagem 1 é possível verificar que a água do açude é quase completa de uma planta conhecida como aguapé. Essa espécie de planta tem uma alta proliferação pois ela cresce se alimentando de composto orgânico e em lagos, rios e açudes que são contaminados por despejo de efluentes ela nasce e se reproduz por todo o espelho d´água.

Na primeira pesquisa de campo foi constatado a poluição nas águas do açude tanto pelo despejo de efluentes não tratados e também pelo lixo que a própria população despeja no Açude e nas margens do mesmo.

Em consulta em sites públicos da prefeitura municipal de Salgueiro - PE estava prevista uma limpeza do Açude em vinte de outubro de 2021, então foi realizado uma segunda pesquisa de campo para a comparação de imagens de antes da limpeza e depois.



Imagem 1



Imagem 2

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Imagem 3



Imagem 4



Imagem 5



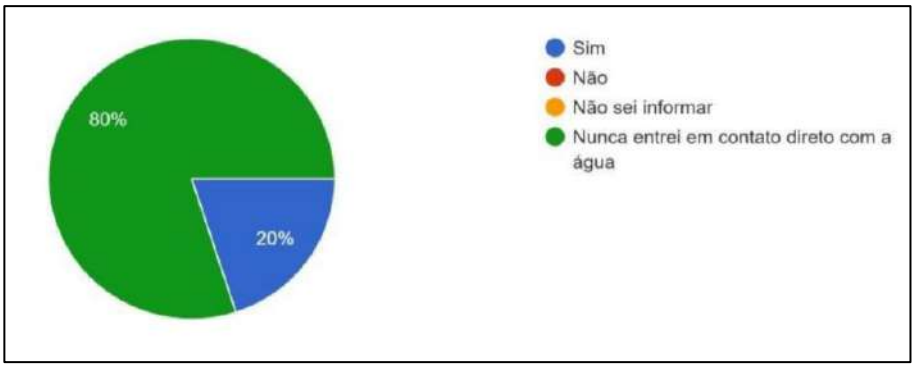
Imagem 6

Fonte: Prefeitura Municipal de Salgueiro-PE/Autor

Figura 2: Açude Velho durante a limpeza

Na figura 2 foram apresentadas imagens do açude recebendo o início da limpeza da água, já tendo sido retirado uma parte dos aguapés e uma grande quantidade de lixo de dentro do açude, como: pneus, garrafas, e lixo doméstico. Ainda não foi constatado em nenhuma fonte do órgão público municipal sobre a situação atual sobre o despejo de efluentes no Açude Velho depois dessa limpeza.

Para uma análise mais aprofundada da situação foi realizado um questionário para moradores da região, foram obtidas cinco respostas para cada questão abordada e contou com o os seguintes resultados:



Fonte: Pesquisa direta

Gráfico 1: Mal-estar após contato com a água do açude

As respostas sobre sentir algum mal estar depois de entrar em contato com a água do açude, 80% respondeu que nunca entraram em contato direto com a água, mas 20% assinalou Sim, que já tinham sentindo alguma reação depois do contato com a água, pois apesar da maioria evitar ainda tem gente que entra na água para tentar pescar algo, acham que a água está limpa e eventualmente sentem algum tipo de mal estar como diarreia, tontura, dor de cabeça ou em pior dos casos algum tipo de doença relacionada a esgoto não tratado como dengue, hepatite A, leptospirose.

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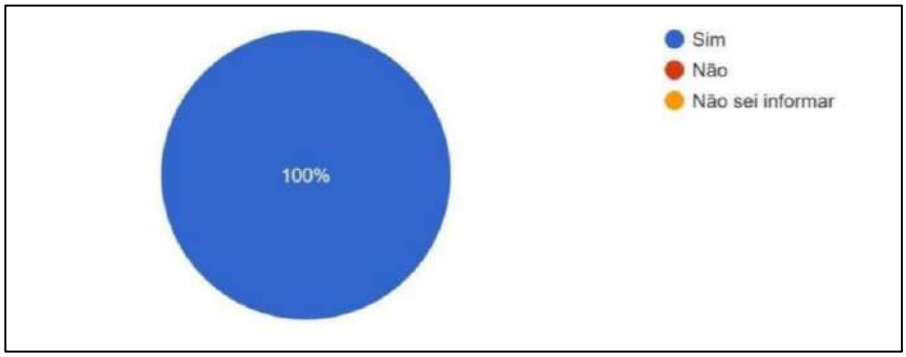
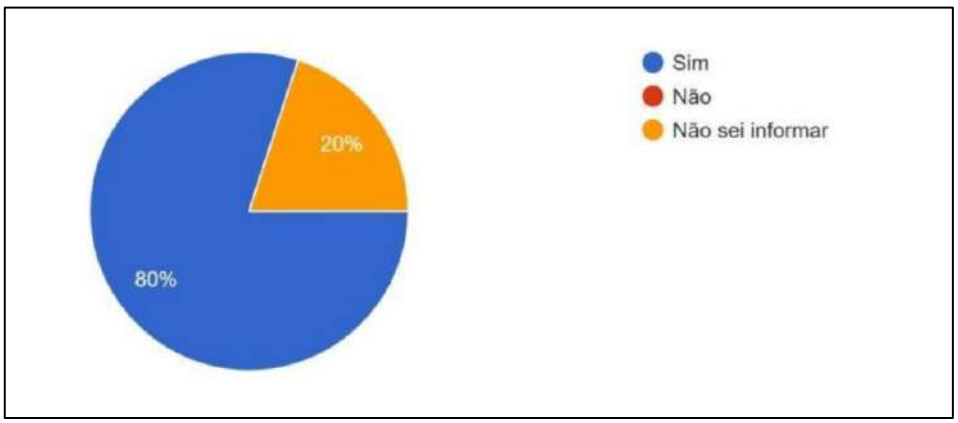


Fonte: Pesquisa direta

Gráfico 2: Mal cheiro na localidade

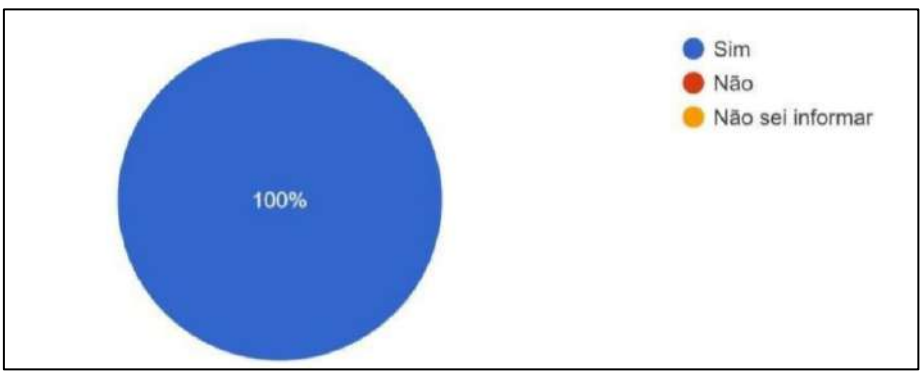
Para a questão de mal cheiro na região do açude as respostas foram unânimes 100% afirmativo, alguns comentários dos moradores sobre essa questão é que o mal cheiro é muito evidente principalmente durante a noite.



Fonte: Pesquisa direta

Gráfico 3: Aumento de mosquitos

No gráfico 3 foi abordado sobre o aumento de mosquitos no bairro do Divino Espírito Santo onde é localizado o açude, grande parte dos entrevistados assinalou afirmativo para o questionamento que indagava sobre aumento de mosquitos por conta do despejo de efluentes no açude. No período da noite a quantidade de mosquitos é bem maior.



Fonte: Pesquisa direta

Gráfico 4: Resíduos no Açude

Essa questão também foi 100% unânime, todos os entrevistados relataram que o lixo é um problema evidente e constante como foi constatado no gráfico 4 e também nas imagens da figura 2 que mostra a quantidade de lixo retirado do açude em uma limpeza da prefeitura.

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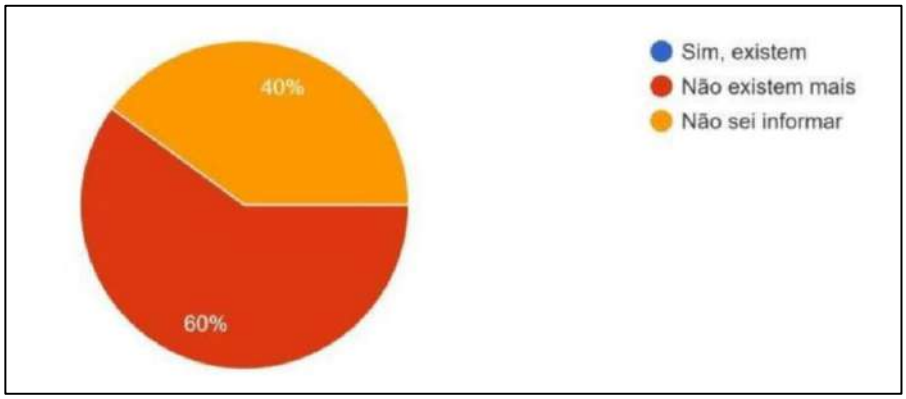

Fonte: Pesquisa direta

Gráfico 5: Existência de animais aquáticos no açude velho

Quando questionado sobre a existência de animais aquáticos no açude velho, a respostas foram quase divididas entre "Não saber informar" e "Não existência". Mas essa questão é derrubada pois na pesquisa de campo foi constatado que ainda existe vida aquática no local.

Diante das respostas percebe-se que o público entrevistado entrou em uma única resposta em pelo menos 2 das 5, com base nisso fica claro que o mal cheiro do açude é uma realidade na localidade do bairro Divino Espírito Santo, assim como o lixo nas margens é um problema constante e incômodo para a grande maioria e boa parte concorda que o aumento dos mosquitos tem relação direta com o açude.

Com a entrevista da profissional de saúde foi possível identificar a situação do hospital nesses tipos de casos. Foram abordadas questões como a frequência de casos relacionados a falta de saneamento, de quais eram as localidades que esses casos chegavam, como normalmente se dava o contágio das pessoas com a falta de saneamento.

As respostas foram bem esclarecedoras que atestam que a cidade ainda carece de saneamento básico principalmente em bairros periféricos e em bairros que estão surgindo na cidade. Segundo a profissional relata as demandas principais que chegam no hospital são crianças com diarreia, vômito e febre, dengue, e raramente casos de hepatite A.

Em relação as localidades dos casos a entrevistada afirma que de onde mais vem casos relacionados a falta de saneamento é dos bairros da Cohab onde alguns esgotos correm a céu aberto, do bairro do Divino Espírito Santo onde se localiza o Açude Velho, e casos de sítios da região onde ainda é comum o uso de poços artesanais que não tem o devido tratamento e onde as crianças tomam banho em poços e em açudes que também não tem tratamento. No caso do surto de dengue e Zika dos últimos anos ela afirma que a demanda de pacientes foi grande, mas que por conta da já existência das Unidades Básicas de Saúde (UBS) foi possível o controle dos casos e a prevenção de futuros.

VII. Considerações Finais

Este artigo possibilitou entender como a falta de saneamento no Açude Velho localizado na área urbana do município de Salgueiro-PE, pode interferir de forma direta na saúde pública, no ecossistema local e na forma de vida dos moradores. Com isso pôde-se perceber a necessidade de uma reformulação do modo de despejo de efluentes no Açude e a criação de algum programa para mudar a situação dos resíduos no espelho d'água.

Para se atingir uma compreensão dessa realidade, definiram-se três objetivos específicos. O primeiro, foi selecionar uma quantidade de referências bibliográficas sobre saneamento básico, Tratamento de esgotos, a criação de açudes e as suas funções para a sociedade. O segundo, entrevistar moradores da localização do Açude Velho para a noção das condições da área estudada. E por último uma entrevista com profissional de saúde para entender como essa questão afeta a saúde pública e apontar os tipos de doenças que podem acontecer e abordar os danos gerados no meio ambiente.

Com a aplicação do questionário foi possível apontar as principais características da região do açude tais como mal cheiro, mosquitos e outros, atendendo ao segundo objetivo. E a entrevista com profissional de saúde foi necessária para entender como a falta de saneamento gera vários tipos de doenças e como é a demanda de casos no Hospital da cidade, atendendo ao último objetivo.

Como já descrito no capítulo de Resultados e Discussão, tem-se, de maneira geral, um fato de que o despejo de efluentes não tratados no Açude tem uma gama de consequências negativas para a população e para os animais aquáticos que vivem ali. Em pesquisas futuras, pretende-se fazer uma outra pesquisa sobre o estado futuro do Açude Velho com as limpezas que estão programadas para os próximos anos.

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Career | Financial



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We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

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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.

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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.

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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.

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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.

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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).

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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.

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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.



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- 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.



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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.

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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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