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<i>Detail with DOI (CrossRef)</i>	
<p><i>The Risks of using Medication for Weight Loss</i> Clara Barros de Souza, Nathan Pedro Saraiva Oliveira, Milena Soares Corrêa, Eugênio Maria Gomes, Kaio Vieira Ramos, Paulo Pereira de Souza, Rafaela trindade Souza, Arthur Martins Freitas, Wanessa Soares Luiz Silva, Daniel Rodrigues Silva  DOI: 10.22161/ijaers.108.1</p>	<p>Page No: 001-006</p>
<p><i>A temperatures variation favor human-elephant conflict in Gabon's Lékédi National Park</i> Djes-Fréys Bilenga Moukodouma, Donald Romarick Rotimbo Mbourou, Christiane Atteke Nkoulembene, Christophe Denis  DOI: 10.22161/ijaers.108.2</p>	<p>Page No: 007-026</p>
<p><i>Ergonomics and Anthropometry in the Design of Doyo Leaf Fiber Softener Machine</i> Dwi Cahyadi, Suparno, Ratna Wulaningrum, Imam Rojiki, Ferry Bayu Setiawan  DOI: 10.22161/ijaers.108.3</p>	<p>Page No: 027-030</p>
<p><i>Playfulness in early childhood education</i> Renata Dias de Freitas, Angelo Ricardo Balduino  DOI: 10.22161/ijaers.108.4</p>	<p>Page No: 031-037</p>
<p><i>The Possibility of using Flared Gas to Generate Electricity using Combined Power Cycle</i> Ubong Nsikak Ubong, Prof. Emenike Wami, Dr. E. O. Ehirim, Prof Etim U Ubong  DOI: 10.22161/ijaers.108.5</p>	<p>Page No: 038-044</p>
<p><i>A Fuzzy Robust Controller for Robotic Systems</i> Lafi Alnufaie  DOI: 10.22161/ijaers.108.6</p>	<p>Page No: 045-050</p>

The Risks of using Medication for Weight Loss

Clara Barros de Souza, Nathan Pedro Saraiva Oliveira, Milena Soares Corrêa, Eugênio Maria Gomes, Kaio Vieira Ramos, Paulo Pereira de Souza, Rafaela trindade Souza, Arthur Martins Freitas, Wanessa Soares Luiz Silva, Daniel Rodrigues Silva

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Keywords— *Slimming, Medicines, Scratches.*

Abstract— *The objective of all this was to evaluate the risks of using drugs in the weight loss process. This research aims to show the importance of using correct medications, prescribed by doctors in a controlled manner, in the weight loss process, encouraging the patient to use non-pharmacological methods to achieve success in weight loss. Methodology: A literature review study was carried out, using the ABNT standards, through the databases, SCIELO (Scientific Electronic Library On-line), MEDLINE, LILACS, Google Scholar, Bireme, Ebsco Host, Pubmed, books and articles published between 2011 and 2021 in Portuguese, English and Spanish, articles that met the following criteria were included: (1) studies that focus on the use of weight loss drugs and their risks (2) studies that are available in full text. Incomplete and unavailable articles were excluded from the bibliographic search. Conclusion: The indiscriminate use of weight loss drugs can cause adverse effects, such as anxiety, heart problems, confusion, insomnia, mood swings and violent behavior. In addition to these disorders, there are psychiatric disorders, including delusions, visual and auditory hallucinations, and delusions.*

I. INTRODUCTION

Obesity is characterized by the accumulation of body fat, which can alter lipid metabolism, induce hormonal changes, increase blood pressure and the onset of heart problems, blood lipids and diabetes. The incidence of obesity has increased in recent years and is currently one of the biggest public health problems, especially in developed and developing countries. (SANTOS, 2016)

In 2012, the World Health Organization (WHO) defined that the individual would be considered obese if he had a body mass index (BMI) equal to or greater than 30 kg / m². Obesity and overweight are the fifth leading cause of death worldwide. There are nearly 3 million adult deaths as a result of being overweight each year. Within this weight range, the risk of dying from diabetes, heart disease, cerebrovascular disease and cancer is much higher. (OLIVEIRA, 2013)

The search for the fastest method to lose weight, stop adapting to what society dictates, in search of a slim body, perfect saying, makes women, especially young people, use drugs to help with weight loss. (SANTOS, 2016); (SAINTS, 2019)

The main therapeutic strategies currently used to combat obesity are diet therapy, an essential basis for therapy, education and behavior modification, increased physical activity and countermeasures against low-life lifestyles, exercise and pharmaceutical therapy.

Obesity is a risk factor for health, it leads to a higher rate of development and progression of diseases, reduces the life expectancy of people with obesity, decreases the quality of life, limits the individual to practice physical activities, in addition to health, mobility, social, occupational and sexual relationships are impaired. (SAINTS, 2019); (NETO et al. 2021)

The use of drugs for weight reduction is indicated when the BMI is greater than 30 kg/m² or when the individual with a BMI greater than 25 kg/m², who has a disease associated with excessive weight, does not obtain satisfactory results with exercises alone physical activities, diets and behavioral changes. The drugs released and indicated as slimming in Brazil are SIBUTRAMINE and ORLISTATE. (SANTOS, 2016); (MARTINS, 2011).

Among the drugs that have had an increase in their sales in recent years, we have PHENTERMINE, an appetite suppressant, which must be prescribed by a specialist and must be used together with the practice of physical exercises, in addition to a hypocaloric diet prepared by a nutritionist. specialist, is a potentially dangerous drug for people who have heart disease, metabolic disorders. (MARTINS, 2011); (SAINTS, 2019)

The use of indiscriminate medications as a way to help in the weight loss process, without the supervision of trained professionals, has grown considerably in the Brazilian population.

II. MATERIALS AND METHODS

A literature review study was carried out, using the ABNT standards, through the databases, SCIELO (Scientific Electronic Library On-line), MEDLINE, LILACS, Google Scholar, Bireme, Ebsco Host, Pubmed, books and articles published between the years 2011 to 2021 in Portuguese, English and Spanish. The Keywords will be “weight loss” and “medicines” and “risks”, in Portuguese, Spanish and English, related to the themes, isolated and grouped together, articles that met the following criteria were included: (1) studies that have as focus on the use of slimming drugs and their risks (2) studies that are available in full text. Incomplete and unavailable articles were excluded from the bibliographic search.

III. RESULTS AND DISCUSSION

Considered a chronic, complex and multifactorial disease, obesity usually begins in childhood or adolescence, where there is an interaction between genetics and the environment. “Energy acquisition and expenditure”. (SANTOS, 2013); (NETO et al. 2021)

Obesity is considered a disease, and it is an increased risk factor for several other comorbidities such as hypertension, dyslipidemia, type 2 diabetes, sleep apnea, cardiovascular diseases, some types of cancer, gallstones, respiratory diseases, insulin resistance and other diseases. (FRANCO, 2014)

In Brazil, the Ministry of Health (MS) released research in 2017 showing that one in five Brazilians is obese. Furthermore, obesity rates also decreased from 11.8% to 18.9% over a 10-year period. According to the Ministry of Health, around 51 million adults living in Brazil were overweight in 2013. Among men, this number exceeds 5%. (MOREIRA, 2020)

The urban lifestyle that the population has lived in recent decades directly affects the increase in food intake, the rush of everyday life, eating out of sight, the lack of financial control to have a good diet, the consumption of fast food, the low water intake, are factors directly related to overweight in the population. (SILVA, 2021)

It should be emphasized that, in obesity, extrinsic factors are more important than genetic ones. The main factors involved in the development of obesity are prolonged exposure to food deprivation, high consumption of processed foods, low consumption of natural foods and neuroendocrine changes. (SILVA, 2021)

The WHO revealed that Brazil has one of the highest obesity rates in the world. Inadequate diet, inadequate health habits and sedentary lifestyle are some of the reasons. Bearing in mind that many of these people will prefer to go the quicker route, which is using appetite suppressants, with the promise of fast weight loss, without sacrifices, and these rates rise even more when the summer approaches. (SAINTS, 2019); (NETO et al. 2021)

Careless use of these drugs (amphetamines and methamphetamines) can lead to long-term dopamine depletion, in addition to loss of the transmitter of this neurotransmitter. Long exposure can lead to excessive weight loss, which is why college students are in high demand, but they overlook other adverse effects such as: anxiety, confusion, insomnia, mood swings, violent behavior, and dental problems. In addition, there are psychiatric disorders, including delusions, visual and auditory hallucinations, and delusions. (SILVA, 2013); (MARTINS, 2011)

In the last 10 years, sales of FENTERMIN, ORLISTAT and FENPROPorex have increased by more than 300%, as they are drugs that promise to help control obesity. In general, people prefer to use appetite suppressants or other drugs that help them lose weight. , in the hope that with the lack of appetite your body will start burning calories, and they generally follow the routine, and lifestyle without physical exercise or a balanced diet. These drugs can cause long-distance consequences such as high blood pressure, pulmonary hypertension and stroke, among others. (SAINTS, 2019); (MOREIRA, 2020)

“Weight loss formulas” are always a combination of medications, one for each part of the organism, one for

the intestine to work better (they cause diarrhea and vomiting), another to calm the individual (a tranquilizer or anxiolytic), in addition to miraculous teas. (SILVA, 2013)

Regarding the treatment of obesity, in the United States of America (USA), the Food and Drug Administration (FDA) is very concerned that people who want to lose weight use drugs that are not labeled only. For cosmetic reasons, drugs such as bupropion, topiramate and fluoxetine are not approved for the treatment of obesity, a phenomenon that also occurs in Brazil. (SILVA, 2013); (SANTOS, 2016)

The term off-label is used when a drug is not used as described and approved in the package leaflet, in situations where the indication for treatment, dosage and route of administration are not indicated. Regulation and approval as well as administration by age group that have not been tested or when the product in use is not registered with a regulatory authority. (BRASIL, 2012), (MARTINS,

2011).

Off-label use can be justified if there is credible evidence and technical rigor to support the intended use, taking care that the desired results are radically different from the approved drug use. In some drugs, unwanted adverse effects may occur, such as weight loss, allowing the use of some weight loss drugs, such as Bupropion, Topiramate and Fluoxetine. (BRASIL, 2012), (MARTINS, 2011).

These drugs alone do not help with weight loss, and their ingestion can cause very serious adverse effects. In all cases, supplements, vitamins and similar products must be prescribed by a doctor and a nutritionist who will include them in the treatment. They can be very harmful, as if left unattended they pose a risk of heart palpitations, increased blood pressure, cardiovascular risk, fatigue and even glaucoma. (BRASIL, 2012), (MARTINS, 2011).

Table 1- Active ingredient of the most used medications in the weight loss process

DRUG	ACTIVE PRINCIPLE	EXPECTED EFFECTS	ADVERSE EFFECTS
sibutramine	A serotonin (5-HT) and norepinephrine reuptake inhibitor, which exerts its effects in vitro through its primary and secondary amine metabolites	Decreases body weight gain with dual action: decreases calorie intake by increasing post-eating satiety responses and increases energy expenditure by increasing metabolic rate	-Lose weight and gain weight again after stopping the medication. -Sibutramine has adverse effects and may cause heart attack.
femproporex	is an agent central stimulant it is a sympathomimetic indirect with effects Similar to Dextroamphetamine		Appetite suppressant, and acuity of taste and odor, leading to individual not ingest a series foods
phentermine	Stimulates the release of nerve endings by increasing the number of postsynaptic receptors; at the opposite pole are the substances that affect the release and reuptake of serotonin		Palpitations, increased heart rate, insomnia, restlessness, dry mouth, diarrhea and constipation.
orlistat	Specific and long acting gastrointestinal lipase inhibitor. It exerts therapeutic activity in the lumen of the stomach and small intestine. It works by inhibiting pancreatic lipase.	Reduces the absorption of fat from food, inhibits the hydrolysis of triglycerides, increasing evacuation by 30%	Fecal incontinence, loose stools, rectal discomfort/pain, dental or gum disorders, lower respiratory tract infections, menstrual irregularities, anxiety, fatigue, urinary tract infection, and abdominal distension.

Saxenda	It is an injectable medication used to lose weight in overweight or obese people, as it helps to reduce appetite and control body weight, and can cause a reduction of up to 10% of total weight, when associated with a healthy diet. of regular physical activity.	It can cause a reduction of up to 10% of the total weight, when associated with a healthy diet and the practice of regular physical activity.	Nausea (sickness), vomiting, diarrhea, constipation
fluoxetine	Antidepressant medication that can help you lose weight, as this is one of its adverse effects. This medicine should only be used under medical advice, because, despite contributing to weight loss, in some cases it can cause the opposite effect to that expected and the person may gain weight	This medicine should only be used under medical advice, because, despite contributing to weight loss, in some cases.	It can cause the opposite effect to what is expected and the person may gain weight. Lost weight is usually regained soon
sertraline	Antidepressant belonging to the group of selective serotonin reuptake inhibitors. It has antidepressant and anxiolytic effects, Used clinically for the treatment of depression, obsessive-compulsive disorder, panic disorder, social phobia, and premenstrual dysphoric		Feeling sick; Headache; Insomnia; Somnolence; Diarrhea; Dry mouth; Dizziness; Feeling tired or weak;
bupropion	Dopamine reuptake inhibitor (DA) and NE Antidepressant more indicated for weight loss than fluoxetine and sertraline, for helping to reduce the compulsion. It acts in a similar way in cases of smokers who want to quit smoking, more indicated when the patient has a psychiatric condition, such as depression or binge eating.	When accompanied by diet and exercise, it can be effective for weight loss.	Difficulty sleeping.
amfepramone	It has effects that seem to be mediated by action on dopaminergic neurons, promoting, like other amphetamine-like drugs, increased dopamine release in presynaptic terminals.	drugs called anorectics, because they act directly on the metabolic system by reducing appetite	Palpitation, rapid heartbeat, increased blood pressure, chest pain, pulmonary hypertension, agitation, nervousness, insomnia, depression, headache, dry mouth, change in taste.
Topiramate	anticonvulsant and used in the chronic treatment of epilepsy and migraine	Used in conjunction with other medications, weight loss is promised	Cognitive slowdown and impaired thinking

Source: Adapted from Santos, p.37, 2019 and Silva, p. 22-23, 2013.

Advertising the use of off-label drugs is prohibited, but their use is not illegal and, in some cases, it may be a clinical option, such as in diseases for which there

is no alternative medicine or when the benefits outweigh the risks. However, the pattern of use involves clinical issues, in addition to ethics and safety in use, which must

be taken into account in the prescription so that it occurs in the safest way, based on scientific evidence. (SANTOS, 2016); (NETO et al. 2021)

If you do not keep in mind certain precautions when taking weight loss pills, not only can you gain more weight instead of losing weight, but it can also be harmful to your health by taking these inhibitors, weight loss cravings, a preliminary consultation with a doctor as mentioned and certain cautions should be considered. (SAINTS, 2019); (NETO et al. 2021)

The use of slimming drugs should be done with caution, as they can cause several adverse effects. The difficulty of accessing qualified medical care increases the number of people who use ineffective treatments, increasing rates of self-medication, making use of herbal preparations with little or no scientific evidence. Study and diet without the supervision of a nutritionist. (SILVA, 2013); (SANTOS, 2016)

A multidisciplinary perspective involving pharmacological, humanistic and social concepts is needed, which replace the mere view of medical therapy and, therefore, promote educational programs aimed at the general population, focusing on the most consumed anorexia medications and their main adverse effects.

Controls on sales in pharmaceutical establishments and restrictions imposed by health laws must be redoubled to reduce the flow of mail orders, sales through online pharmacies and sales of real estate, legally without a prescription. (SILVA, 2013)

The drugs used in the treatment of obesity are controversial, due to practices such as inappropriate use, excessive prescription, excessive use of measures containing drugs for weight loss and downgrading of traditional treatments, system, combination of diet and exercises and changing habits. (SANTOS, 2016); (NETO et al. 2021)

In order to have a good result in the treatment of obesity, a balanced and healthy diet, nutritional monitoring, periodic physical exercises are necessary, that is, changing the lifestyle, which is difficult to find or do for a subgroup of patients, who need pharmacological assistance to solve the problem with the scale.

The history behind drug therapy for obesity is surrounded by pitfalls and dilemmas regarding efficacy, abuse and adverse effects, as already proven the risk of valvular disease, pulmonary hypertension associated with phentermine, fenfluramine, which had its use discontinued some time ago. 13 years ago, because of cardiovascular risk. These episodes prompted regulators to set strict requirements for approving a drug to treat obesity.

(SANTOS, 2016); (SAINTS, 2019); (NETO et al. 2021)

Obese patients who want to use medications to help them lose weight should therefore know about the possible adverse effects that the medications can cause, have multidisciplinary follow-up, in addition to changing habits, eating habits and life, such as practicing physical exercises together. of drug treatment.

One of the rates of indiscriminate use of slimming drugs, most are university students (MARTINS, page 02, 2011), who have troubled schedules and prefer to look for the fastest way to lose weight, but the adverse data of prolonged use without it is in conjunction with physical exercises and a good diet are harmful to health.

IV. CONCLUSION

Using weight loss drugs indiscriminately can cause adverse effects, cardiovascular problems, anxiety, confusion, insomnia, mood swings and violent behavior. In addition to these disorders, there are psychiatric disorders including delusions, visual and auditory hallucinations, and delusions.

Medical and specialized follow-up for the use of such drugs is extremely important, doctors such as endocrinologists and nutrologists are indicated for the surveillance of patients who intend to use drugs to aid weight loss.

Just take medicine if there are permanent results in the body, there are many reports of people who used "faster" strategies and the phenomenon of the accordion effect occurred, where individuals lose weight, but gain weight again as soon as they stop taking the medication, which in its natural it cannot be used for long periods of time.

Physical exercise and dietary re-education are the first strategies that doctors and nutritionists ask patients to do, as they are long-lasting and changing life habits has much more results than the use of medications, but if the patient even with the change does not get results, the use of medications associated with exercise and a good diet does have a good expectation of results.

Therefore, it is possible to conclude that the use of drugs for weight loss for an indefinite period causes cardiac, physical and mental consequences in people who consume them, making us think about the intake and sale of this medication to audiences such as university students, and that the prescription and Correct medical follow-up is essential.

In view of the material available in educational bases on the subject, it is important that other articles like

this one are prepared on a scientific basis so that professionals can base themselves using them.

REFERENCES

- [1] BRAZIL, Ministry of Health. Off-label use: error or necessity? Rev. Public Health: Institutional Technical Reports, Brasília, v. 46, no. 2, p.398-399, 2012.
- [2] Franco, RR, Cominato, L., & Damiani, D. (2014). The effect of sibutramine on weight loss in obese adolescents. *Brazilian Archives of Endocrinology & Metabology*, 58(3), 243–250. <https://doi.org/10.1590/0004-2730000002825>
- [3] Gomes, JS (2016). The irrational use of herbal medicines in weight loss: A literature review. <http://repositorio.faeima.edu.br:8000/jspui/handle/123456789/410>
- [4] Carvalho e Martins, M. do C. de, Souza Filho, MD de, Moura, FS, Ribeiro de Carvalho, J. de S., Müller, MC, Neves, RV, Mousinho, PC, & Lima, IP (2011) . Use of anti-obesity drugs among university students. *Journal of the Brazilian Medical Association*, 57(5), 570–576. <https://doi.org/10.1590/S0104-42302011000500017>
- [5] Moreira EF, Almeida IM, Barros NB de, & Lugtenburg CAB (2021). What are the risk-benefits of sibutramine in the treatment of obesity? *Brazilian Journal of Development*, 7(4), 42993–43009. <https://doi.org/10.34117/bjdv7n4-659>
- [6] Neto, BB de C., Neto, IF, Souza, V. de A. de, Sousa, FDA de, Marques, A. EF, & Pereira, LR de AB (2021). Use of medication for weight loss by higher education students in the health area at a private educational institution in the city of Cajazeiras, Paraíba, Brazil. *Health and Environment Magazine Environment*, 12(1), 167–179.
- [7] Oliveira, IC de, & Cordeiro, PB de MH (2013). Phytotherapeutics as Adjuncts in the Treatment of Obesity. *Cadernos UniFOA*, 8(1 (Esp.)), 97–104. <https://doi.org/10.47385/cadunifoa.v8.n1>
- [8] Santos, C. de SC, & Belo, RFC (2017). Prevalence of drug use for weight loss in university students from Sete Lagoas - mg. *Brazilian Journal of Life Sciences*, 5(1).
- [9] Santos, KP dos, Silva, GE da, & Modesto, KR (2019). Danger of slimming drugs. *Journal of Scientific Initiation and Extension*, 2(1), 37–45.
- [10] Silva, RR and, & Abreu, PA (2021). Teas and slimming: A critical analysis of what is being recommended in youtube videos. *Health and Environment Magazine*, 12(1), 235–248.
- [11] Silva, LFO da, Silva, FVM da, & Oyama, SMR (2013). Prevalence of weight-loss drugs among university students: Prevalence of weight-loss drugs among university. *Revista Recien - Scientific Journal of Nursing*, 3(7), 19–26.

A temperatures variation favor human-elephant conflict in Gabon's Lékédi National Park

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Keywords— *Unavailability of Moabi tree fruit, temperatures, elephant movement, Lékédi National Park, human-elephant conflict.*

Abstract— *The purpose of the study, conducted from August 8th to 12th, 2022, in Gabon's Lékédi National Park, was to assess elephant movement in relation to the availability of Moabi tree fruit. The goal was to understand the close connection between fluctuating temperatures and elephant movement toward human habitations. A questionnaire was utilized to gather insights from 53 individuals, primarily adults residing around Lékédi National Park. Statistical analysis of the collected data revealed a significant correlation between the percentage of individuals noticing changes in Moabi tree productivity and variations in mean annual temperature. The mean annual temperature had increased by +0.06°C over the two consecutive 5-year intervals between 2011 and 2020 (study period). The survey indicated that 56.6% of respondents perceived the Moabi fruit harvest as average in the last two years, and around 90% of people had witnessed their own or a relative's field being devastated by elephants during the same period. Notably, 96.23% of respondents believed that present-day elephants are getting closer to human dwellings, compared to 3.77% who thought they were moving farther away. The lack of available Moabi fruit would encourage elephants to venture into secondary forests, thereby escalating the risk of human-elephant conflict.*

I. INTRODUCTION

Interest in comprehending temperature and rainfall variations in Africa arises from their impact on fauna, flora, and human life, often leading to human-elephant conflicts [1,2]. Climate change-related phenomena such as drought, flooding, and desert encroachment pose serious threats to elephant populations in certain Central African regions [3]. A study conducted in Côte d'Ivoire's Sikensi Park revealed that elephants are increasingly entering human settlements, damaging crops, food supplies, and water sources [4]. Research has indicated that most elephants in Cameroon's

Mbam and Djerem National Park prefer settling in young colonial forests [5]. In Burkina Faso, over 80% of the population considers elephants insignificant due to their significant crop damage, as they're consistently seeking food to meet their high dietary requirements. They reportedly consume around 450 kg of food daily [7]. Forest elephants primarily feed on fruit [3], as well as grass [2].

Similarly, human-elephant conflicts exist in Gabon, as evidenced by a tragic incident in September 2021 that claimed a truck driver's life in Mouila, southeast Gabon [8]. Damage to human crops is also noticeable. A study in the

Massaha village in Makokou, northeast Gabon, demonstrated that 77% of surveyed families had encountered fields ravaged by elephants [9]. Residents near Gabon’s Lékédi National Park report elephants damaging fields and water sources, while also encroaching closer to human habitats [10]. However, the impact of temperature and rainfall changes on human-elephant conflict acceleration remains underexplored [1,11]. This study aims to depict temperature changes in Lékédi National Park and highlight fluctuations in Moabi fruit availability during the same period. Moabi fruit constitutes 80% of elephants’ preferred food and is a crucial part of their diet. Additionally, the study aims to observe elephant migratory behavior toward human settlements.

This study holds particular significance, as it deepens the understanding of temperature variation’s impact on human-elephant conflict acceleration within the Lékédi National Park Reserve. Temperature fluctuations can alter plant and fruit availability for elephants. Furthermore, this study serves as a wake-up call, emphasizing the urgent need for increased attention to climate variations by populations and governments, given their potentially irreversible consequences on people’s daily lives.

II. STUDY AREA

The present study was conducted in eastern Gabon (Figure 1) and focused on the Sébé-Brikolo department, with

Okondja as its chief town. The population primarily comprises indigenous groups, particularly the Obambas. Other groups, such as the Bakaningui and Tékés, are also present but in smaller numbers. The area has low overall population density, approximately 1.1 inhabitants per square kilometer. The Lékédi climate experiences four seasons, including two rainy and two dry seasons, with an average annual temperature of 25.1°C. The landscape predominantly features forests and a variety of animal species, including the protected and dominant elephant species. The vegetation is diverse, including the highly valued Nkumou, a main delicacy in Okondja.

The present study was carried out in eastern Gabon (Figure 1). The study area is located in the department of Sébé-Brikolo, whose chief town is Okondja. The population is predominantly made up of indigenous peoples, specifically the Obambas. In addition, there are a few Bakaningui, Tékés and other peoples. The area is sparsely populated overall, with a population density of around 1.1 inhabitants/km². The Lékédi climate has four seasons, including two rainy seasons and two dry seasons, with an average annual temperature of 25.1°C. The vegetation is largely made up of forests and animal species, including a protected and predominant species: the elephant. The vegetation abounds in a wide variety of species, including the highly prized Nkumou, one of Okondja’s main delicacies.

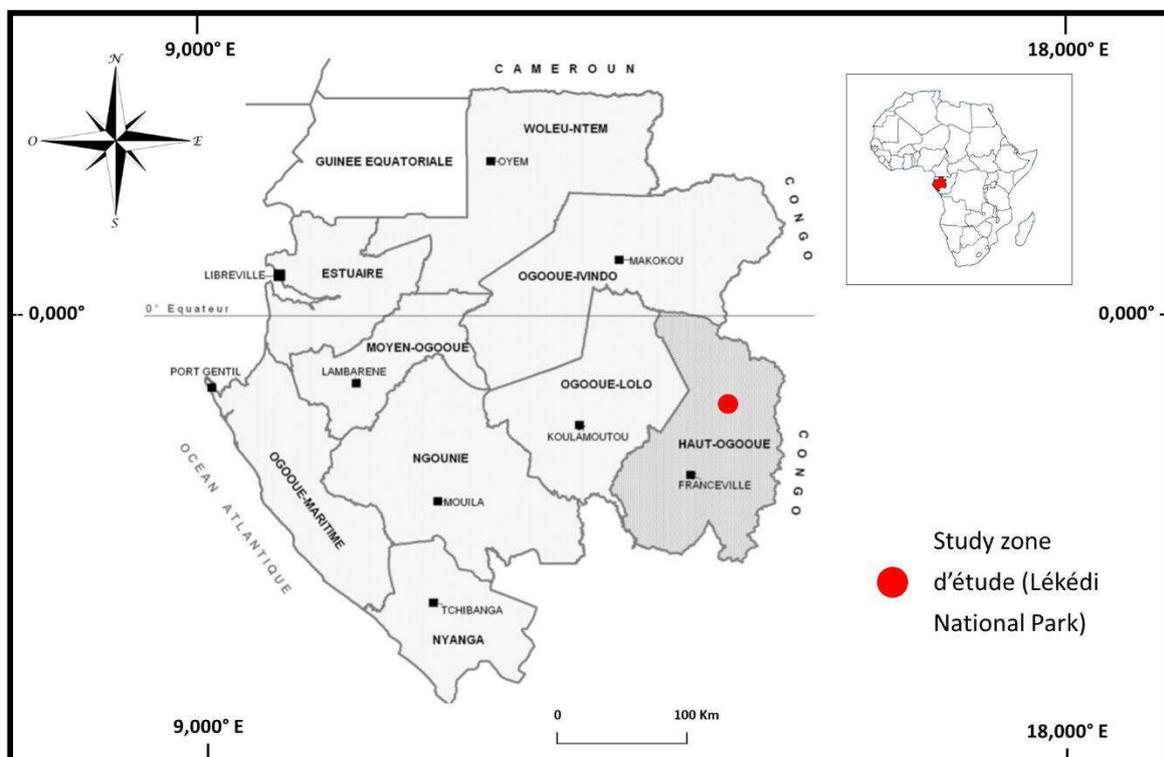


Fig.1: Location of the study area [source internet].

In this region, agriculture stands as the dominant activity, serving as the primary source of both food and income for the local population. A significant portion of the bananas exported to the provincial capital, Haut-Ogooué, Franceville, originates from this area. Additionally, Haut-Ogooué plays a crucial role in cassava cultivation [12]. Recognizing this potential, the United Nations Development Program launched the Art Gold program in 2007, aiming to foster the region's development [12]. Consequently, the Lékédi region serves as a vital link within the food supply chain for neighboring communities.

III. METHODOLOGY

The survey, combined with statistical analysis of data and the evaluation of temperature change between 2011 and 2020 in the study area, facilitated the examination of elephant movement concerning the availability of Moabi fruit. Information about the frequency of observing elephant droppings, elephants near or distant from houses, the preferred food of elephants, knowledge of the Moabi tree, and the percentage of people affected by elephant-induced field devastation was collected through a form modeled after the African Elephant Specialist Group's questionnaire [4]. A series of interviews was conducted with a group of 53 mainly adult participants, accounting for approximately half of the population residing near the Lékédi park. This approach was due to the low density of 1.1 inhabitants per square kilometer in an area of about 140 square kilometers. Only the interviewer had access to the questionnaire, and solely conducted interviews with local residents. Certain questions included a "miscellaneous" option to capture unexpected responses and gather comprehensive information.

For questions concerning elephant sightings near or far from human dwellings, the available response options were "none," "one," and "several." Questions related to incidents or accidents involving elephants, awareness of the Moabi tree, and the elephant's most preferred food had binary options "yes" or "no." For the preferred elephant food, the choices encompassed fruit, leaves, and an "other" category to account for unexpected responses. Based on the

appearance of Moabi fruit, the available options were specific months of the year. Solutions to the human-elephant conflict were proposed as follows: cessation of hunting, population relocation, elephant eradication in the study area, and establishment of a more distant elephant reserve. Using Microsoft Excel 2021, an Excel spreadsheet containing all collected data was generated.

Once the Excel table was established, statistical analysis was conducted using our AdvDatAna (Advanced Data Analysis) toolbox, customized for database analysis. This toolbox facilitated descriptive statistical analysis of survey form data. All graphs, including the graph depicting temperature trends sourced from the National Climatic Data Centre (CNDC) database, were created using Microsoft Excel 2021. Accessing CNDC's online data requires utilizing FTP (File Transfer Protocol) software such as FileZilla Client. This database is one of the leading meteorological databases globally, incorporating data from the National Oceanic and Atmospheric Administration (NOAA) satellites and ground sensors. It differs from data obtained from the Climatic Research Unit (CRU), often utilized in various studies, which tends to be less precise due to reanalysis or simulated calculations. With ground-based data becoming scarcer [14], the Okondja station presented limited measurements possibly due to equipment issues. As a result, the Franceville-Mvengué station, located around 200 km from the study area, was selected for its comprehensive meteorological parameter measurements. Regrettably, temperature data from June 2021 to December 2021 were absent. Notably, initial temperatures in this database were presented in degrees Fahrenheit (°F). To calculate average temperatures (Tables 1a and 1b) in degrees Celsius (°C), initial temperatures were converted using the formula: $T(^{\circ}\text{C}) = (T(^{\circ}\text{F}) - 32) / 1.8$. Subsequently, various values were compared to ascertain the month with the highest or lowest mean annual temperature. The statistical series was divided into two equally sized sub-series (each containing five values). The mean annual temperature for each sub-series was determined separately, and the temperature difference between these two five-year periods was calculated, thus highlighting the temperature variance over these two periods.

Table 1a : Temperature trends from 2011 to 2021 (January to June) at the Franceville-Mvengué station [source: CNDC].

Year	Months (1/2)					
	January	February	March	April	May	June
2011	22,57778	24,20556	24,46112	23,56667	24,66667	23,40556
2012	23,83334	23,01112	25,01667	24,77778	23,51112	23,27778
2013	24,92778	25,43334	24,11667	24,88889	23,79445	22,85
2014	24,44445	24,18334	24,31667	24,55	23,4	23,29445
2015	23,92223	24,26112	23,79445	23,57223	23,4	22,77778
2016	24,44445	24,55556	24,74445	24,03334	24,08334	23,11112
2017	23,62223	23,90556	23,77778	23,85	23,27778	23,25556
2018	23,72223	24,02778	23,81667	23,63889	23,42223	23,03334
2019	24,22778	25,27778	25,66112	25,18334	24,49445	24,08889
2020	25,12223	24,42223	25,05	24,66667	23,99445	23,01667
2021	22,36112	24,52223	23,31112	23,66667	22,77778	

Table 1b : Temperature trends from 2011 to 2021 (July to December) at the Franceville-Mvengué station [source: CNDC].

Year	Months (2/2)					
	July	August	September	October	November	December
2011	24,17223	23,00556	24,01667	23,54445	23,12778	23,92223
2012	22,58889	21,78889	23,75556	23,18889	23,46112	23,41112
2013	22,57778	22,98889	24	23,67223	23,7	23,81667
2014	23,83334	22,59445	23,57223	23,61667	23,25556	23,29445
2015	22,86667	23,07778	23,61112	23,65556	23,47778	24,22778
2016	22,47223	23,22223	24,01667	23,45556	23,52223	24,24445
2017	22,34445	22,86667	24	23,42223	23,18334	23,52778
2018	22,34445	23,04445	23,79445	23,16667	23,22223	23,33334
2019	23,22223	23,05556	23,94445	23,00556	23,46667	23,72223
2020	22,97223	23,22223	24,18334	23,83334	23,16667	23,58334
2021						

Once the temperature table had been clearly highlighted using the two previous sub-tables (Tables 1a and 1b), a quarterly comparison followed, which involved averaging three consecutive months per year, then comparing the results of the various quarterly averages with each other. After the quarterly comparison, a half-yearly comparison was also carried out. This consisted in calculating the average temperature after six months, i.e. two half-years per year. This was followed by two seasonal comparisons (type 1 and 2). The type 1 seasonal comparison is based on the mean temperature determined over two seasons (dry and rainy). In concrete terms, this involved grouping temperatures by season, according to the corresponding month, and then establishing a comparison between the dry and rainy season averages. The Type 2 seasonal comparison

follows the same principle as the first, i.e. to determine the average temperature per season, this time carried out over the four seasons, i.e. two dry seasons (long and short) and two rainy seasons (long and short). We then compare the averages obtained for each season and year.

Finally, we determined the correlation between the percentage of people observing changes in Moabi fruit harvesting and average annual temperatures. By calculating the correlation coefficient, we were able to highlight the degree of relationship between the two variables.

The main stages of the methodology followed are listed in the flow chart in figure 2, and the mathematical background is developed in the appendix.

1	Bibliographic research	<input type="checkbox"/> Knowledge of the Moabi tree <input checked="" type="checkbox"/> Impact of climate change on biodiversity
2	Form creation	<input type="checkbox"/> Observing the african elephant specialist group form <input checked="" type="checkbox"/> Defining the questions on my form
3	Choice of data collection site	<input type="checkbox"/> Importance of the site for local populations <input checked="" type="checkbox"/> Recurrent observation of human-elephant Conflict
4	Material and type of population to be interviewed	<input type="checkbox"/> Material : Survey form <input checked="" type="checkbox"/> Target population: adults and young people
5	Collecting data	<input type="checkbox"/> Filling in a form for each interviewee <input checked="" type="checkbox"/> Verification of all forms
6	Data processing	<input type="checkbox"/> Transcription of data into a Microsoft Excel 2021 file <input checked="" type="checkbox"/> Application of statistical processing with the AdvDatAna toolbox
7	Results	<input type="checkbox"/> Analysis and interpretation of results <input checked="" type="checkbox"/> Decision-making and recommendations

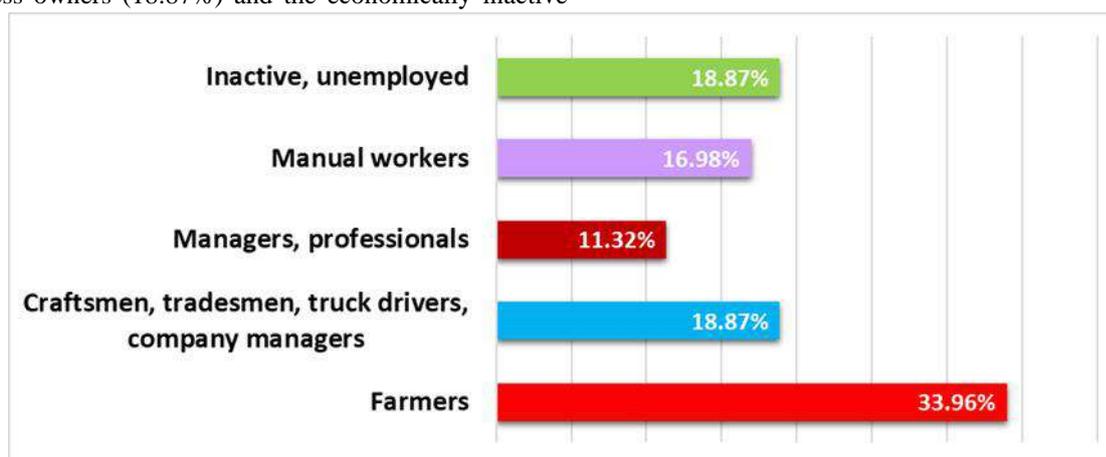
Fig.2: Steps in the methodology.

IV. RESULTS

The majority of respondents were farmers (33.96%), followed by craftsmen, shopkeepers, truck drivers and business owners (18.87%) and the economically inactive

without stable employment (18.87%) (Figure 3a). The most represented age group is 30-39 (39.62%), followed by 20-29 (18.87%), 15-19 (15.09%), and 40-49 and 50-60 (13.21%) (Figure 3b).

a)



b)

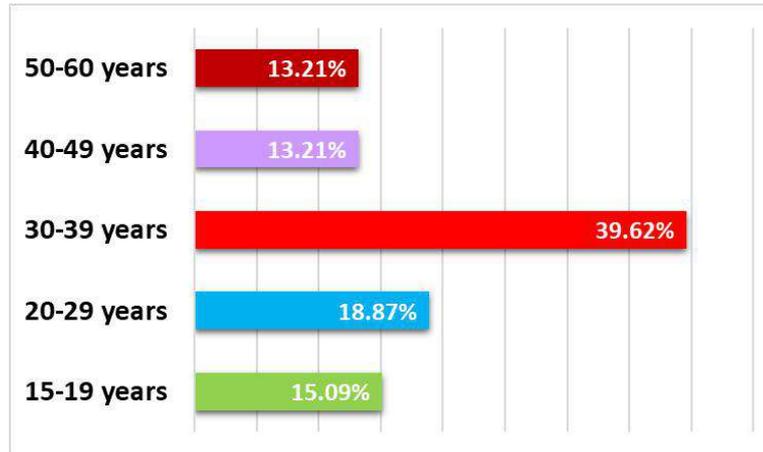
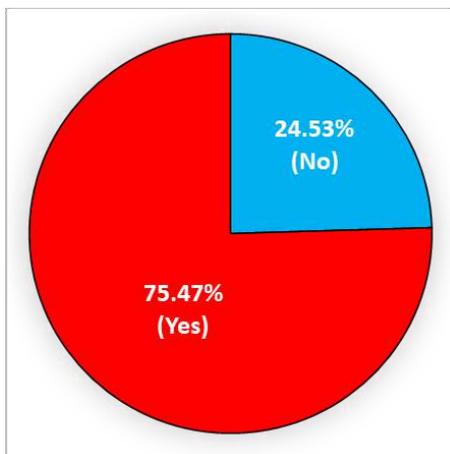


Fig.3 : Information on the survey population: a) socio-professional category, b) different age groups of respondents.

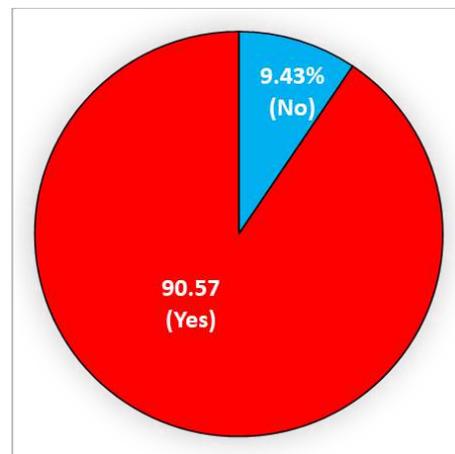
During the study period, no particular situations were observed or reported. However, more than 70% of those questioned had already had an accident with an elephant, or knew someone in their immediate environment who had had an accident with an elephant in the last 5 years. The proportion of such people is shown in Figure 4a. When asked how many piles of elephant dung they see per week in their plantation, 50.94% of people claim to encounter several per week in their field, 18.87% encounter at least one pile of elephant dung, and 30.19% see no elephant waste at all (Figure 4b). In terms of knowledge of the Moabi tree, 90.57% of those questioned were familiar with it,

compared with 9.43% for whom it was unknown (Figure 4c). With regard to the food that elephants are fond of, over 60% of respondents felt that they feed mainly on fruit, as opposed to 32.08% who thought they preferred leaves. 1.89% gave a combined answer, i.e. they thought the elephant ate leaves and bark or fruit and bark, while 1.89% gave no opinion (Figure 4d). Concerning the month of greatest production of the Moabi tree, 50.94% of respondents felt that Moabi fruit is produced abundantly in May each year, compared with 18.87% who thought it was in April, 15.09% in March and 1.89% in the remaining months (Figure 4e).

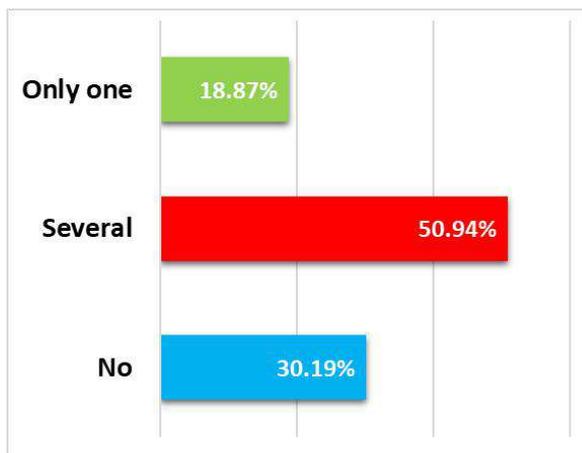
a)



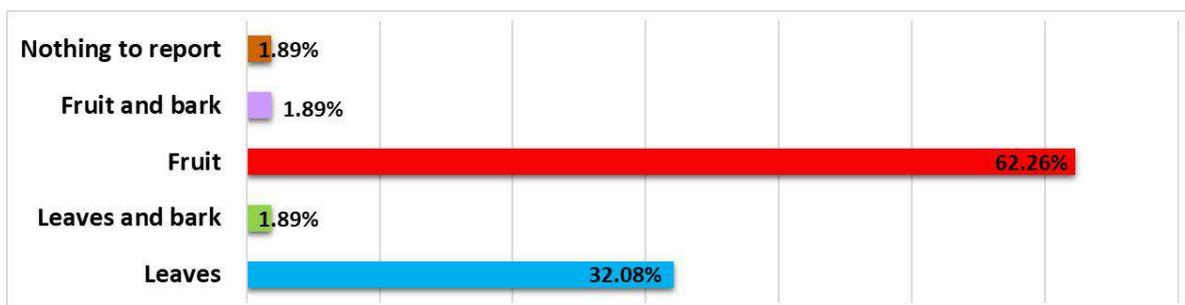
c)



b)



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e)

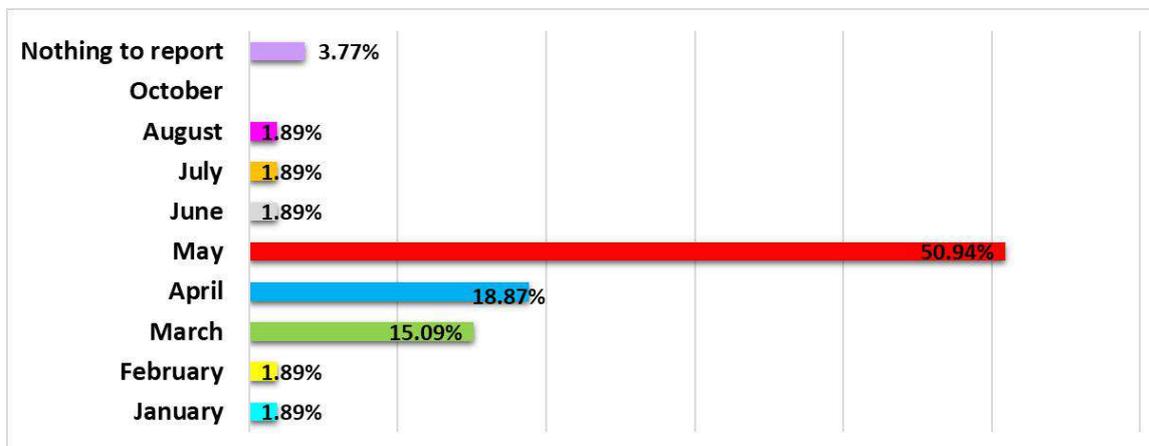


Fig.4: Practical information on elephants and villagers' knowledge of the Moabi tree: a) percentage of people with or without an elephant accident in the last five years, b) proportion of people seeing at least one pile of elephant dung per week in the field, c) proportion of people with or without knowledge of the Moabi tree, d) elephant's favorite food, e) months of abundant Moabi tree fruit productivity.

With regard to the quality of the harvest over the last five years, 56.6% of those questioned felt that the harvest had been average. 35.85% said it had been poor, and the remainder were undecided (Figure 5a). Speaking of the year in which changes occurred in Moabi tree production, 69.81% felt that the Moabi fruit harvest fell in 2021, 16.98%

that it fell in 2020, 1.89% that it fell considerably in 2019, and the remaining percentage was unable to give an answer (Figure 5b). Answering the question “Do you think the elephant is closer to human habitation or further away?”, 96.23% of respondents gave a favorable answer, compared with 3.77% who answered unfavorably (Figure 5c).

The percentage of people who observed changes in the harvesting of Moabi fruit was strongly correlated with the average annual temperatures of the years under consideration (Figure 5d), with a correlation coefficient of $r = -0,99$. This strong negative correlation translates into a decrease in average temperatures over said years, while the percentage of observations increases (Figure 5d).

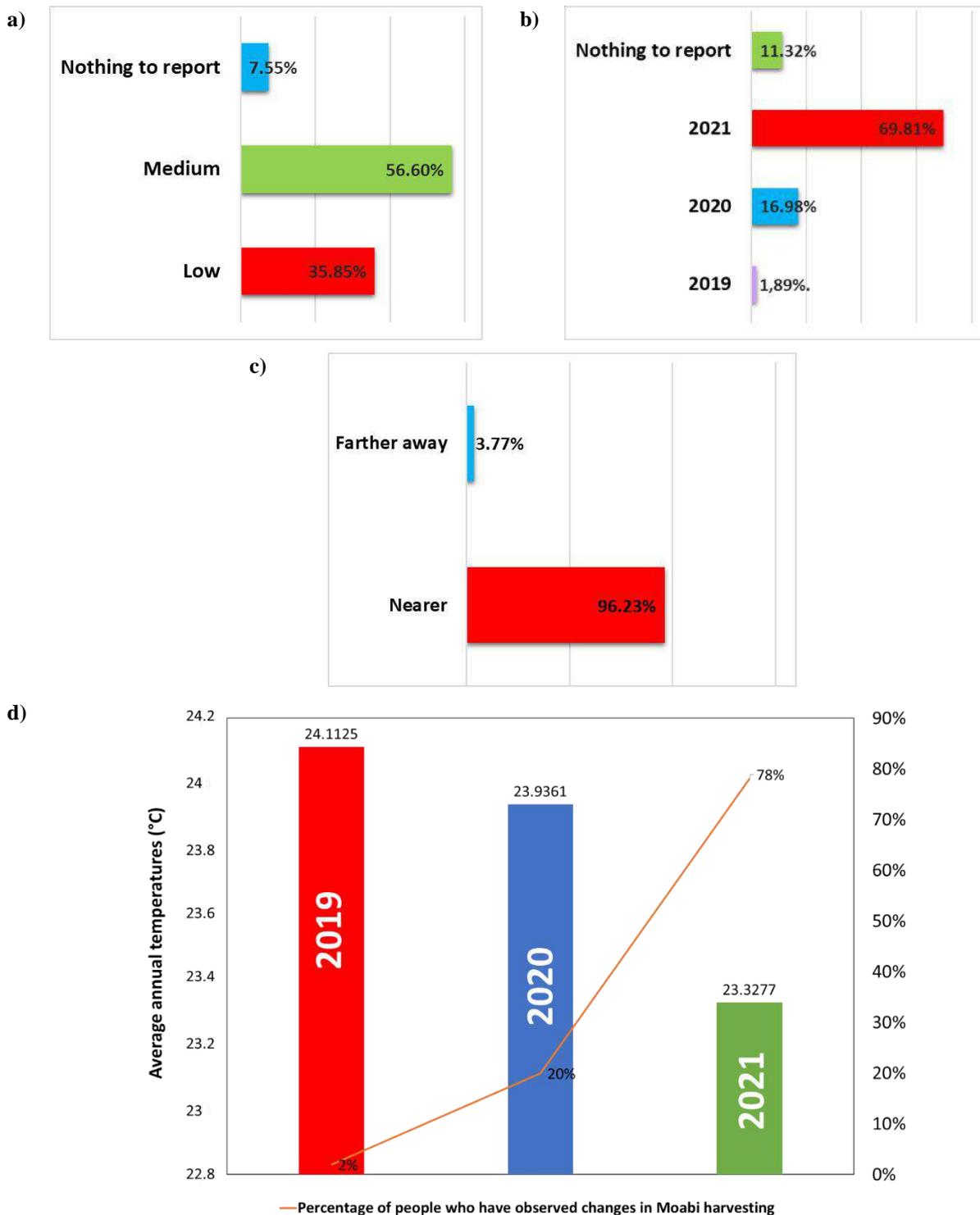


Fig.5 : Quality of Moabi fruit harvest in recent years and proximity of elephant to human dwellings: a) proportion of Moabi fruit harvest in recent years, b) year of low Moabi tree productivity according to villagers, c) position of elephant in relation to human dwellings, d) correlation between temperatures and percentage of people observing changes in Moabi fruit harvest.

On the subject of crop fields devastated by elephants, almost 90% of those questioned had already suffered damage, and 10% had experienced no elephant-related damage.

People use a variety of techniques to protect their fields and crops. The majority (15.09%) use the duo of “watchtowers and repellents such as fire” (Figure 6a). According to them, this duo has borne fruit, even though it requires considerable physical effort and sacrifice, such as chopping wood at every vigil to make fire. This activity also

results in a significant reduction in the wake-keepers’ sleep time. In order to avoid the long-term damage caused by elephants, people believe it would be advisable to consider the following options: 67.93% of those questioned were convinced that the best solution would be to create a fenced reserve for elephants, 7.55% opted to give up hunting and create a reserve for elephants at the same time. The remaining 26.41% fell into the other categories shown in figure 6b.

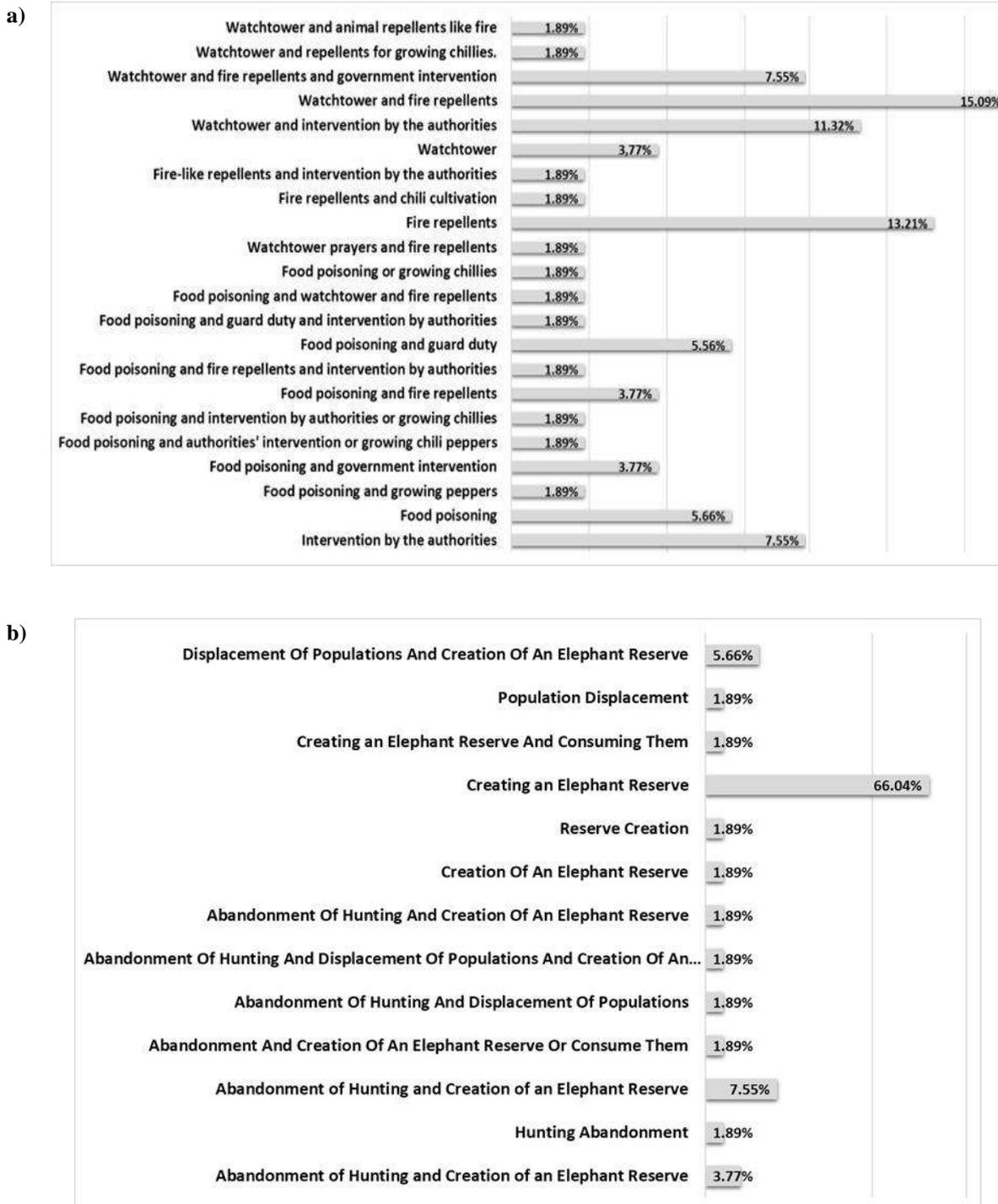


Fig.6 : Proposed solutions to human-elephant conflict: a) various elephant deterrence techniques, b) solutions proposed by villagers to curb human-elephant conflict.

The study of temperatures was the second major part of our work. This was divided into three sub-steps. Firstly, the evolutionary curve of mean annual temperatures (Figure 7) revealed that these oscillated between 23.3°C and 24.2°C over the 2011-2021 period.

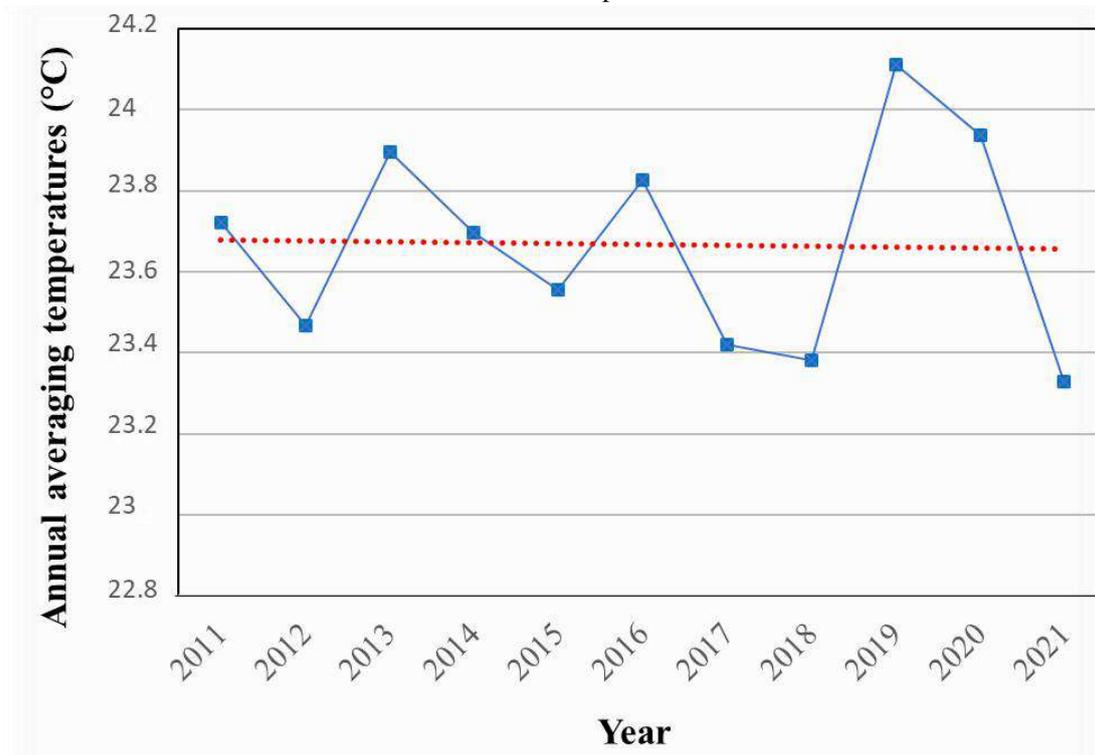
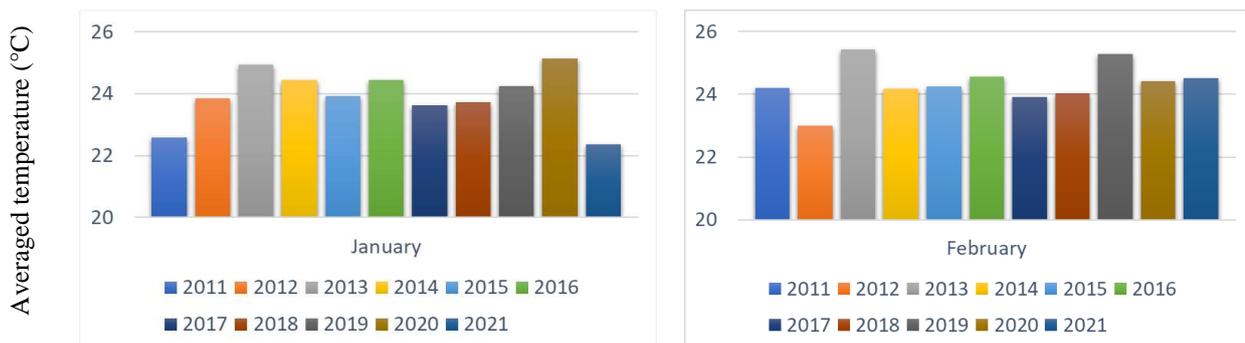


Fig.7: Trends in mean annual temperatures over the period 2011-2021

The monthly histograms of mean temperatures over the 2011-2021 period (Figures 8a and 8b) show that August 2012 was the month with the lowest mean temperature ($T= 21.8^{\circ}\text{C}$), while February 2013 was the month with the highest mean temperature ($T= 25.4^{\circ}\text{C}$). The mean annual temperature rose by $+0.06^{\circ}\text{C}$ between the two 5-year periods in Lékédi National Park.



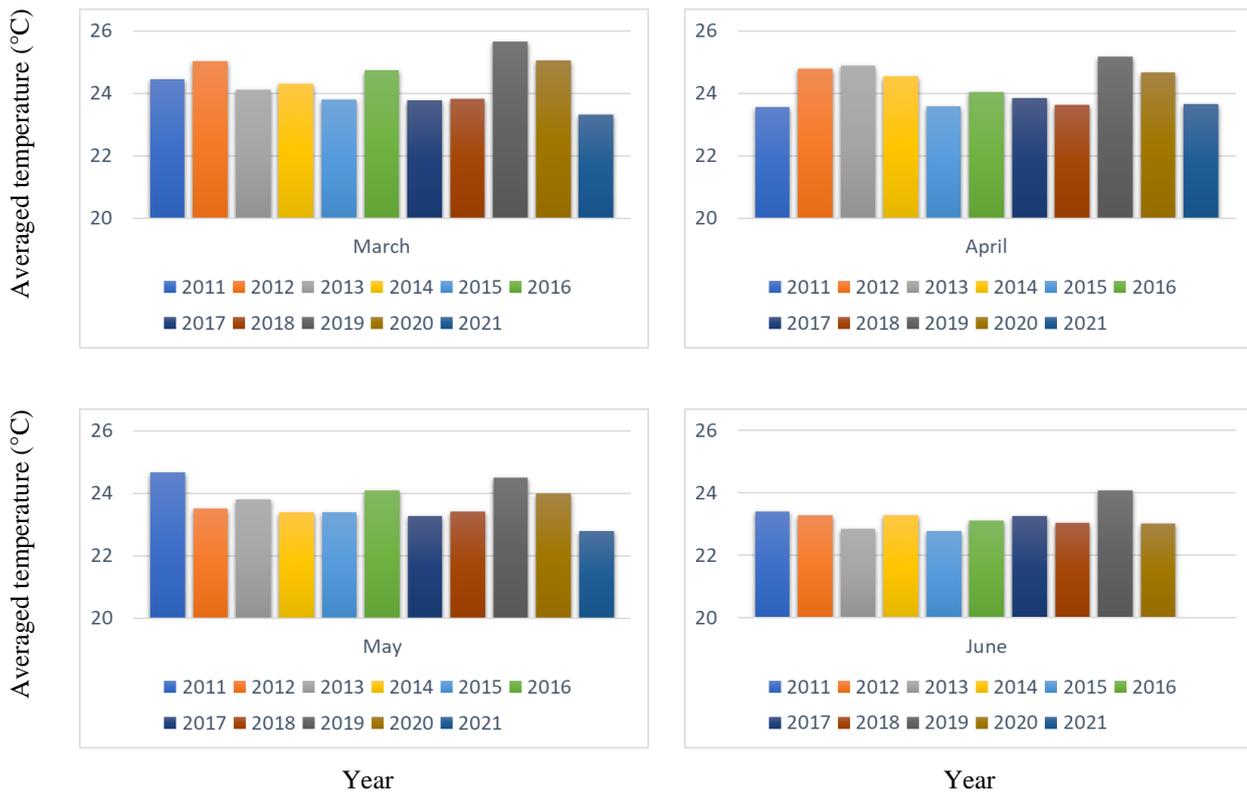


Fig.8a: Average monthly temperatures measured at the Franceville-Mvengué station from 2011 to 2021 (January to June) [source: CNDC].



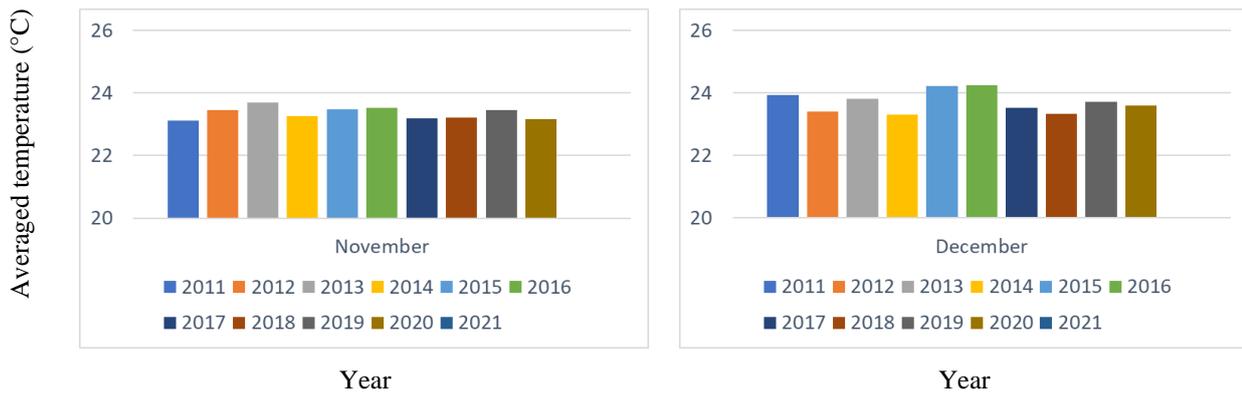


Fig.8b: Average monthly temperatures at the Franceville-Mvengué station, over the period 2011 to 2021 (July to December) [source: CNDC].

Lastly, the comparisons of quarterly and half-yearly averages may not be very indicative, but they do reveal that the first quarter and the first half-year of 2019 were the hottest (Figure 9a and Figure 9b).

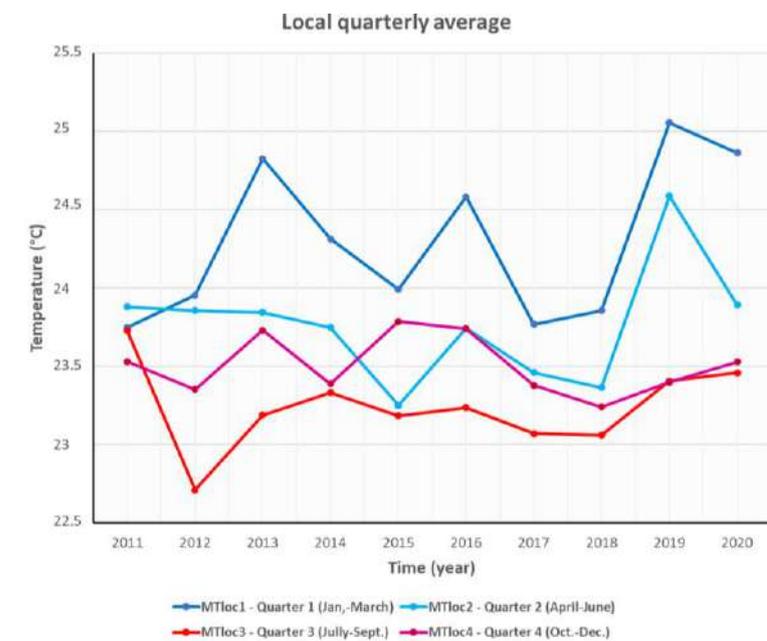
The Type 1 seasonal comparison yielded two significant findings. Firstly, in 2019, both the dry and rainy seasons were the warmest, with temperatures of 23.94°C and 24.29°C, respectively. However, we also note a slight increase in temperature during the rainy season compared to that in the dry season (Figure 9c). This minor temperature increase ranges from [0.26% to 4.20%] (Table 2a). However, this increase was observed in all years except 2014, when the temperature during the rainy season slightly decreased by 0.30% compared to that in the dry season (Table 2a).

The Type 2 seasonal comparison revealed that the short rainy season of 2019 was the warmest (25.11°C) among the three other seasons. Nevertheless, it's important to note that in any given year, all the major dry seasons have lower temperatures than their minor counterparts. From the long dry season to the short dry season, we observe a slight temperature increase. The percentage increase in temperature generally falls within the range of [0.17%; 8.42%] (Figure 9d, Table 2b).

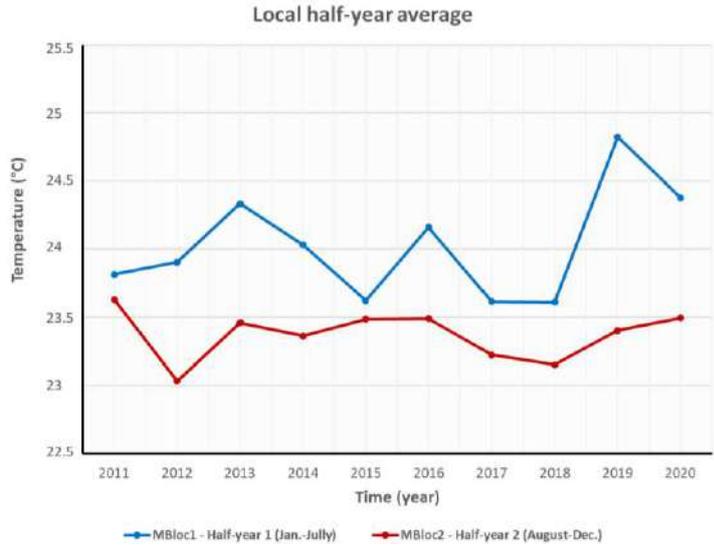
From one year to the next, the average temperature sometimes decreases (as in 2011 and 2012, for example) and sometimes increases (as in 2018 and 2019) (Table 3).

Additionally, the highest rate of temperature increase was recorded in 2019 (3.13%), as shown in Table 3.

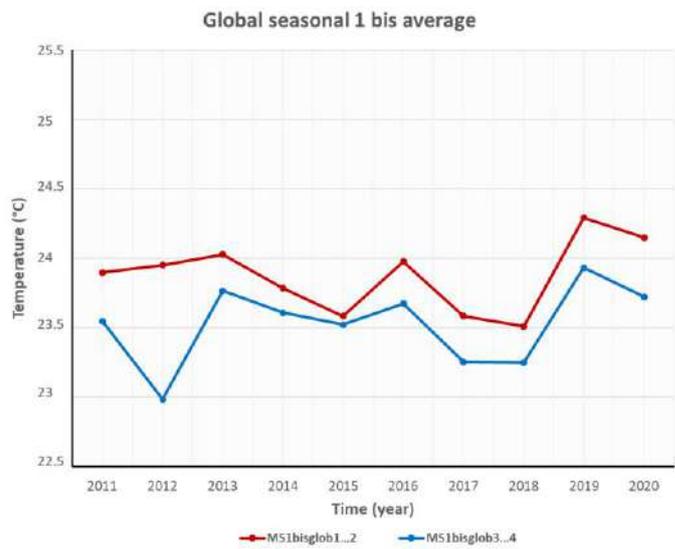
a)



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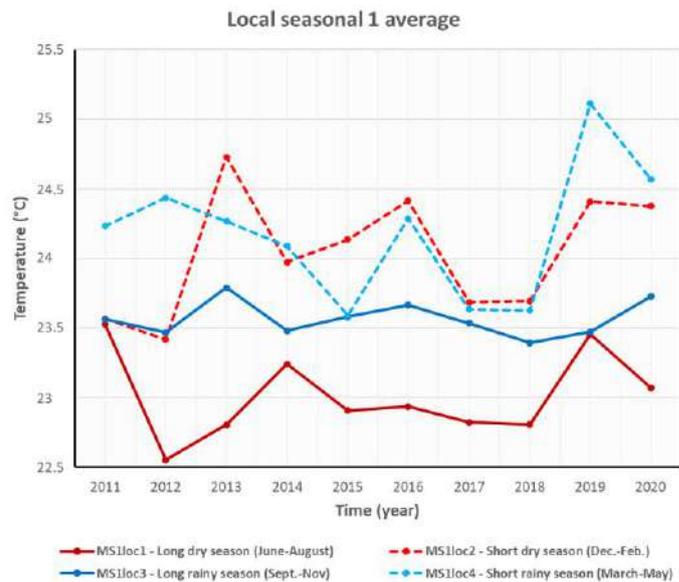


Fig.9 : The different temperature comparisons: a) quarterly comparison, b) half-yearly comparison, c) global seasonal comparison 1, d) local seasonal comparison 2

Table 2a : Temperature trends in the dry and rainy seasons from 2011 to 2021 at the Franceville-Mvengué station [source: CNDC].

Year	Temperature en °C (dry season)	Temperature en °C (rainy season)	Percentage increase
2011	23.54814	23.89723	1.48%
2012	22.98518	23.95185	4.2%
2013	23.76574	24.0287	1.1%
2014	23.8574	23.78518	-0.3%
2015	23.52223	23.58518	0.26%
2016	23.675	23.97592	1.27%
2017	23.2537	23.58518	1.42%
2018	23.25092	23.51018	1.11%
2019	23.9324	24.29259	1.5%
2020	23.72314	24.14907	1.79%

Table 2b : Temperature trends during the long and short dry seasons from 2011 to 2021 at the Franceville-Mvengué station [source: CNDC].

Year	Temperature en °C (long dry season)	Temperature en °C (short dry season)	Percentage increase
2011	23.52778	23.56851	0.17%
2012	22.55185	23.41851	3.84%
2013	22.80556	24.72592	8.42%
2014	23.24074	23.97407	3.15%
2015	22.9074	24.13703	5.36%
2016	22.93518	24.41481	6.45%
2017	22.82223	23.68518	3.78%
2018	22.8074	23.85556	4.59%
2019	23.45556	24.40925	4.06%
2020	23.07037	24.37592	5.65%

Table 3 : Rate of temperature increase between two consecutive years in the 2011-2020 study period, at Franceville-Mvengué station [source: CNDC].

Year	Average annual temperatures	Rate of increase between two successive years
2011	23.72269	0,00%
2012	23.46852333333333	-1.071%
2013	23.897225	1.82%
2014	23.69630083333333	-0.84%
2015	23.55370833333333	-0.6%
2016	23.82546916666667	1.15%
2017	23.41944833333333	-1.7%
2018	23.38056083333333	-0.16%
2019	24.112505	3.13%
2020	23.93611666666667	-0.73%

V. DISCUSSION

A survey carried out in Lékédi National Park suggests that elephants have a strong preference for fruit. More than 60% of those questioned said they were fond of fruit such as the Moabi tree, which grows predominantly in the park. The survey also revealed that elephants are now closer to human settlements; 96.23% of respondents

supported this assertion. Elephants are a real danger to humans. In fact, over 70% of those questioned said they had already had an accident with an elephant. The survival of the people living near the Lékédi park is threatened, as most of them depend on agriculture. The destruction of plantations by elephants means the disappearance of people's main sources of subsistence. The average annual

temperature rose by $+0.06^{\circ}\text{C}$ between the two 5-year periods in Lékédi National Park during the decade between 2011 and 2020. A slight warming of the Lékédi park is noticeable. Indeed, we noted an increase ranging from 0.26% to 4.20% in temperature in the rainy season compared with the dry season. This conclusion is reinforced by the 0.17% to 8.42% rise in temperature in the short dry season compared with the long dry season. There is a close link between the availability of Moabi fruit and elephant migration to human settlements, with a strong negative correlation ($r = -0,99$).

This survey of the indigenous populations of the Lékédi region revealed that over 70% of respondents had already experienced at least one unfortunate event involving elephants. In cases where respondents were not directly involved, it was a close relative who was. At the same time, around 90% of respondents claimed to have had at least one crop field devastated by elephants. Elephants have enormous nutritional needs [15]. Deprived of the fruit of the Moabi tree, which they love and are the main disseminators [16], elephants migrate to secondary forests. These forests, to which elephants migrate, are generally areas cultivated by local populations. This migration of elephants in search of food could explain the high percentage of people who have had an incident with an elephant. This finding is in line with Aimeric Ferlay's [9] work in three villages in the Makokou region, which showed that almost 77% of families surveyed had experienced at least one field ravaged by elephants.

During the survey, we noted that the majority of people (90.57%) interviewed were familiar with the Moabi fruit, suggesting that it is or was prevalent in the study area. The Moabi tree is said to play many roles in people's daily lives, with its numerous curative, culinary and other properties [1]. The Moabi tree therefore remains of vital importance to the people of this region. This is confirmed by the International Union for Conservation of Nature (IUCN), which has added the Moabi to its list of vulnerable species [15].

According to the testimonies of the people questioned, 62.26% believe that the forest elephant has a food preference for fruit; 32.08% believe that it prefers leaves and 1.89% think that it consumes leaves and bark, fruit and bark and the remaining 1.89% did not give an opinion, probably due to a lack of knowledge of the elephant's diet. These observations suggest that the elephant feeds mainly on fruit rather than leaves or bark. This is in line with the work of Bush [16]. The latter showed that a drop in fruiting led to an 11% reduction in the body condition of forest elephants, suggesting a dependence on fruit.

We found that over half (50.94%) of those surveyed felt that the Moabi tree produced more in May, while 18.87% chose April, 15.09% March and 1.89% the rest of the months. These results suggest that the margin in terms of fruiting months for the Moabi tree lies in the March-May range. The March-May range corresponds to the short rainy season, during which Gabon's climate generally alternates between mild hot spells and mild cold spells [17], resulting in an almost permanent minimum temperature during this period. This may be in line with the work of Bush, who argues that certain tree species require a minimum temperature to trigger flowering [16]. However, the 1.89% of people who opted for the rest of the months are not necessarily making a mistake. This is undoubtedly due to a disruption in the reproductive calendar of certain tree species during these months. This disruption would be due to climate change, as suggested by a study carried out in Uganda in 2018 [18]. It claimed that the modification of certain climatic signals had favored changes in the reproductive cycle of certain trees.

The elephant now seems to be closer to human habitation than to its natural environment, the forest. The data suggest that 96.23% of those surveyed claim that the elephant is closer to them than it used to be. Similarly, 69.81% of the sample claimed to find at least one pile of elephant dung per week in their field, compared with 30.19% who found no piles of elephant dung, probably due to the irregular use of their fields, as some of them had already suffered the devastating effects of elephant passage. All these observations confirm the hypothesis that the elephant is closer to the population these days. Certainly, this could be due to the absence of a food that elephants are fond of, the fruit of the Moabi tree, as emphasized by Nanfack [5] and Guibinga [6]. However, this could be the result of the gradual degradation of the elephant's ecosystem with the rise of manganese mining by Gabon Mining in the Okondja locality. This seems to accord with a recent survey by Afrobarometer [19], in which they suggest that Gabonese people blame logging and mining for exacerbating human-wildlife conflict. These results are in line with the survey conducted by the Wildlife Conservation Society (WCS) and the Agence Nationale des Parcs Nationaux (ANPN), which implied that the elephant population had increased from 7330 individuals in 2014 to around 95,000 elephants in Gabon by 2021 [8], thus proving the overpopulation of this species in the Gabonese forest. These results are confirmed by recent unfortunate events in the town of Mouila (southern Gabon), where an elephant killed a bus driver on the main road where buses and trucks travel [8]. On January 26 and 27, 2023, a man and a woman were mauled by elephants in the villages of Ilahounene and Iyoko Ngota respectively. Both are located in the Ogooué

Ivindo region (south-east Gabon) [20]. These recent tragedies clearly demonstrate that elephants are deserting their natural habitat to move into areas previously occupied and frequented by humans.

The absence of the Moabi fruit, which elephants love, is thought to have driven them to the local crop fields. This assertion is supported by the work of Bush. This work argues that the fruiting of trees in natural forests has fallen dramatically over the last thirty years, encouraging elephants to move out of the forest [16].

To deal with this animal threat, the majority of respondents (15.09%) use the "watchtower and fire repellent" duo to keep elephants away from their crop fields. This technique is said to play a positive role in keeping elephants away from homes. However, its implementation requires considerable effort, i.e. huge amounts of wood to be cut for the fire, which would accelerate the desertification process in the area [21]. Burning wood increases the release of carbon dioxide (CO_2) into the atmosphere, contributing to global warming [11]. In the long term, it is also said to cause sleep disturbance for the guards, who have to keep vigil over and over again. While some opted for intervention by the authorities (7.55%), others believed in the use of food poisons (5.66%), which would not be good practice as the elephant is on the IUCN Red List of Vulnerable Species and is therefore a fully protected species [22]. On the other hand, a section of the population has opted to grow large quantities of chilli trees around the crop fields. This would make sense, as elephants might be disturbed by the pungent smell of chillies. Planting chilli trees around crop fields would be a viable avenue to explore in Lékédi National Park. It could be of dual importance: to protect the crops, and to help increase people's incomes after exporting and selling the chillies to major markets. All these techniques do not seem to be fully supported by the work of Ouattara [4], who considers their effectiveness to be temporary. In fact, these studies show that elephants become accustomed to traditional human techniques over time, and their response to the signals emitted by humans diminishes considerably over the long term.

In an attempt to eradicate the human-elephant conflict caused by the absence of Moabi fruit in Lékédi National Park, some 67.93% of people felt that it would be a good idea to create a fenced reserve to contain the elephants. Some even suggested that it should be electrified, which would be a continuation of the electric fencing program that has already proved successful in various protected areas in Gabon [23] and northern Congo [22]. However, their implementation would pose a serious dilemma in terms of high installation costs. We might also ask what would be

the long-term impact of electric discharges on the pachyderms? Would they lead to infertility? Despite the growing interest in this approach, a long-term study of pachyderm fertility would be welcome. A small percentage (1.89%) opt for abandoning hunting and suggest population relocation. However, this would further increase the vulnerability of populations that depend mainly on forest resources [24]. This solution would also increase the poverty of the Lékédi population, most of whom live off agriculture. This observation is partly endorsed by Thomas Breur [7], who considers that while abandoning hunting and the rural exodus may appear to be a legitimate resolution to spare people the worst, it would nonetheless have serious consequences for family food supplies. Hill's work in 2018 [25] highlighted the fact that farmers are rarely compensated in the event of forced rural exodus, thus demonstrating the limits of the proposed solution of population displacement.

The average annual temperature in Lékédi Park has risen by $+0.06^\circ C$ between two 5-year periods, leading to a considerable drop in the Moabi fruit harvest, as suggested by more than half of the natives in 2021. Indeed, 69.81% believe that it was in 2021 that the Moabi fruit harvest dropped considerably, and 16.98% think it was in 2020. These observations underline the significant changes that began in the tenth year of the study period. These results are in line with those of Bush [1], who showed a rise in daily minimum temperature of $+0.25^\circ C$ per decade in Lopé. In addition, the temperature in the rainy season was higher than in the dry season, and the temperature in the short dry season was 0.17% to 8.42% higher than in the long dry season. These different temperature variations would influence the productivity rate of the Moabi tree. All these factors would explain the decline in Moabi tree productivity, since based on the experience of the local population, the tree produces better during the short rainy season. This hypothesis is confirmed by the Intergovernmental Panel on Climate Change (IPCC) [26], which states that rising temperatures and the occurrence of more frequent and prolonged extreme events are affecting the biosphere at several levels (species distribution, phenology, ecosystem structure).

There is a strong negative correlation ($r = -0.99$) between mean annual temperatures and the percentage of people observing changes in Moabi fruit harvesting. The increase in one variable (average temperature) would favor a decrease in the reproduction of Moabi fruit, thus explaining the drop in the harvest of this fruit observed by people from the year 2019 onwards. 2019 also recorded the highest rate of increase between two consecutive years. This rise in temperature may be man-made, with manganese extraction in the Okondja region by Nouvelle Gabon

Mining (NGM) beginning in earnest in 2019. This assertion is supported by the IPCC, whose latest report states that global warming is unprecedented and caused by human activities [20]. There is a close link between climate signals (temperature and precipitation) and plant production. Nevertheless, we deplore the absence of precipitation data. The non-exploration of rainfall data is due to their relative unavailability due to the small number of rain gauge stations in Central Africa [27]. Changes in these climatic variables would therefore have an impact on the reproductive cycle of certain trees [7]. This supports the idea that an increase of one hundredth of a degree Celsius in mean annual temperature influences the reproductive process of Moabi. This correlation has also been proven by Bush [16], whose work in the Lopé reserve revealed the existence of a minimum temperature for triggering flowering in certain trees.

VI. CONCLUSION

The inhabitants of Lékédi National Park are under serious threat from the movement of elephants. Elephants migrate towards human settlements in search of food. Their movement is correlated with the availability of Moabi fruit in their natural habitat. Moabi fruit is highly prized by pachyderms, and its harvest has declined considerably in recent years. Statistical analysis of the data collected during the survey suggests that elephants are moving closer and closer to human habitations, and that an increase in mean annual temperature (+0.06°C) between two 5-year periods would favour a decrease in Moabi fruit reproduction. Higher temperatures during the rainy season and the short dry season, compared with the long dry season, are indeed reasons for the drop in Moabi fruit production. The results of this study therefore allow us to assert that a change in temperature in the Lékédi National Park leads to a scarcity of Moabi fruit, which in turn drives elephants towards people's crop fields. This study has also enabled us to sound the alarm once again, urging the authorities to focus more on this little-studied area, which is nevertheless a strong link in the supply of foodstuffs such as bananas, a foodstuff much appreciated by the populations of the surrounding localities. The Gabonese government has decided to release 4 billion FCFA in May 2023 to compensate populations suffering the effects of the human-elephant conflict. This palliative solution is not sustainable in the long term, as the populations concerned are numerous. Concrete solutions are therefore urgently needed.

The current study can therefore be strengthened by applying it to other national parks. It would also be advisable to carry out a survey of victims of human-elephant conflict living outside national parks. In addition

to these studies, a real awareness campaign on the elephant's major role in ecosystem conservation should be carried out among the local population. The absence of temperature data for the rest of the months in 2021 is an obstacle to our study. On the one hand, it would be necessary to acquire all temperature data, preferably even daily data, for all the years from 2011 to 2022, and on the other hand, to take an interest in the quality of rainfall in Lékédi. This acquisition could be carried out using machine learning tools. All this would enable experimental studies to be reinforced, as has been the case in the Lopé reserve by numerous researchers.

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REFERENCES

- [1] E. R., Bush. Tropical Phenology In A time of Change, Thèse de doctorat, Université de Stirling, Décembre 2018.
- [2] F., Nsonsi. Les conflits homme-éléphant (*Loxodonta cyclotis*): Un défi pour les communautés locales à la conservation de la faune 2018.
- [3] E.M.S., Belle, N.D., Burgess, M., Misrachi, Impacts du changement climatique sur la biodiversité et les aires protégées en Afrique de l'Ouest, Résumé des résultats du projet PARCC, Aires protégées résilientes au changement climatique en Afrique de l'Ouest. Rapport UNEP-WCMC, Cambridge, Royaume-Uni :52p, 2016.
- [4] F.A., Ouattara, O., Soulemane, A., Nandjui, E.J., Tondoh, Etat des maraudes et des dégâts de cultures liés aux éléphants à l'ouest du secteur de Djouroutou dans le sud-ouest du Parc National de Taï (Côte d'Ivoire), Pachyderm No 47, 2010.
- [5] A., Nanfack Impacts des activités humaines sur la population des éléphants dans le parc national du Mbam et Djerem. Mémoire de master. Université de Yaoundé I,2016.
- [6] G., Guibinga, Les Maraude des éléphants (*Loxodonta Africana africana*) et techniques de dissuasions mises en œuvre par les populations autour de la forêt classée des deux Balé, Mémoire ingénieur, Université Nazi Boni (UNB), Novembre 2018.
- [7] T., Breur, S., Ngama, Les hommes et les éléphants de forêt en Afrique centrale : Conflits et coexistence dans et autour des aires protégées, Etat des Aires Protégées d'Afrique centrale 2020.

- [8] M., Dorothée. Mouila : l'éléphant à l'origine de la mort d'un chauffeur termine dans les marmites, Journal Gabon actu, 09 Septembre 2021.
- [9] A., Ferlay, Analyse des activités agricoles et forestières en forêt dense d'Afrique centrale : cas des trois villages de la région de Makokou au Gabon ,2014.
- [10] R., Ndemanou, La problématique de gestion des aires protégées en Afrique centrale : le cas du parc national de la Lopé au Gabon, Journée mondiale de l'environnement.2015.
- [11] K., Abernethy, E.R., Bush, P.M., Forget, I., Mendoza &L.P.C., Morellato, Current issues in tropical phenology: a synthesis, Biotropica 50 :477-482, 2018.
- [12] Programme Art Gold Gabon, Appui aux réseaux territoriaux pour la gouvernance locale et le développement, province du Haut-Ogooué, Ministère de la planification et de la programmation du développement en partenariat avec les agences du système des Nations Unies PNUD, UNESCO, UNIFEM, UNICEF, OMS, UNITAR, UNOPS,2023.
- [13] D.R., Rotimbo Mbourou, Toolbox_AdvDatAna_2020y12m21d19h08m, GitHub.Retrieved May 20,2021.
- [14] E.R., Bush, K., Jeffery, N., Bunnefeld, C., Tutin, R., Musgrave, G., Moussavou, V., Mihindou, Y., Malhi, D., Lehmann, J., Edzang-Ndong, L., Makaga, K., Abernethy, Rare ground data confirm significant warming and drying in western equatorial Africa. PeerJ8 : e8732,2020.
- [14] D., Ndiade Bourobou, Dynamique spatiale et temporelle de la diversité génétique d'une espèce rare en Afrique Centrale : baillonella toxisperma Pierre (le Moabi), Thèse de doctorat. Université de Montpellier, Avril 2011.
- [15] E.R., Bush, R.C., Whytock, L., Bahaa-el-din, S., Bourgeois, N., Bunnefeld, A.W., Cardoso, J.T., Dikangadissi, P., Dimbonda, E., Dimoto, J.E., Ndong, K.J., Jeffery, D., Lehmann, L., Makaga, B., Momboua, L.R.W., Momont, C.E.G., Tutin, L.J.T., White, A., Whittaker, K., Abernethy, Long-term collapse in fruit availability threatens Central african forest megafauna, Science,2020.
- [16] M., Edou, E., Ondo Assoumou, La diversité biologique au Gabon : contexte et enjeux, Annales de l'Université Omar Bongo, No16, 2011.
- [17] C.A., Chapman, K., Valenta, T.R., Bonnel, K.A., Brown, L.J., Chapman, Solar radiation and ENSO predict fruiting phenology patterns in a 15-year from Kibale National Park, Uganda, Biotropica 50, 384-395,2018.
- [18] B.C., Wakongo Nzamba., S., Ondo Zé, Les Gabonais accusent l'exploitation forestière et minière d'exacerber le conflit homme-faune, Afrobarometer No 409, Novembre 2020.
- [19] L., Ekomba Ndombe, Conflit homme-faune : Un homme et une femme mortellement agressés par des éléphants, Union du 27 Janvier 2023.
- [20] GIEC, 6^e rapport de synthèse sur les changements climatiques, Mars 2023.
- [21] T.M., Brncic, Expérimentation d'une clôture électrique afin de limiter les ravages des éléphants sur les cultures dans le Nord du Congo, Etat des Aires Protégées d'Afrique Centrale, 2020.
- [22] S., Avomo Ndong, Human-wildlife conflict and ecotourism: comparing Pongara and Ivindo National Parks in Gabon, Master thesis, University of Oregon, USA,2017.
- [23] K., Abernethy, F., Maisels, L.J.T., White, Environmental issues in Central Africa, Annual review of Environment and Resources 41(1):1-33,2016.
- [24] C.M., Hill, Crop foraging, crop losses, and crop raiding, Annual Review of Anthropology 47:377-394,2018.
- [25] GIEC, 6^e rapport d'évaluation sur les changements physiques : La base scientifique physique, Août 2021.
- [26] R., Washington, R., James, H., Pearce, W.M., Pokam, W., Moufouma-Okia. Congo basin rainfall climatology: can we believe the climate models? Philosophical Transactions of The Royal Society of London, Series B, Biological Sciences 368:20120296,2013.

Appendices

Mathematical background

The various average calculations in this article are based on this mathematical background.

In the following, M_i^k will be the variable denoting average temperatures for month no. i of the year k .

Overall annual average

The average temperatures obtained, for the year 2011 only, will be noted $MA_{glob}^{k=2011}$ and calculated as :

$$MA_{glob}^{k=2011} = \text{mean} \left(\sum_{i=1 \dots 12} M_i^k \right) .$$

The vectors corresponding to the period from 2011 to 2020 will be expressed as :

$$MA_{glob}^{k=2011 \dots 2020} = [MA_{glob}^{k=2011}, MA_{glob}^{k=2012}, \dots, MA_{glob}^{k=2019}, MA_{glob}^{k=2020}] ;$$

Local half-year average

The average local temperatures obtained during semesters 1 and 2, for 2011 only, will be respectively $MB_{loc1}^{k=2011}$ and $MB_{loc2}^{k=2011}$ and calculated as follows :

$$MB_{loc1}^{k=2011} = \frac{\sum_{i=1...6} M_i^k}{6}, MB_{loc2}^{k=2011} = \frac{\sum_{i=7...12} M_i^k}{6}.$$

The vectors corresponding to the period from 2011 to 2020 will be expressed as :

$$MB_{glob1}^{k=2011...2020} = [MB_{loc1}^{k=2011}, MB_{loc1}^{k=2012}, \dots, MB_{loc1}^{k=2019}, MB_{loc1}^{k=2020}];$$

$$MB_{glob2}^{k=2011...2020} = [MB_{loc2}^{k=2011}, MB_{loc2}^{k=2012}, \dots, MB_{loc2}^{k=2019}, MB_{loc2}^{k=2020}];$$

Overall half-year average

The average local temperatures obtained, for the year 2011 only, will be noted $MB_{glob1...2}^{k=2011}$ and calculated as follows :

$$MB_{glob1...2}^{k=2011} = \text{mean}(MB_{loc1}^{k=2011}, MB_{loc2}^{k=2011})$$

The vectors corresponding to the period from 2011 to 2020 will be expressed as :

$$MB_{glob1...2}^{k=2011...2020} = [MB_{glob1...2}^{k=2011}, MB_{glob1...2}^{k=2012}, \dots, MB_{glob1...2}^{k=2019}, MB_{glob1...2}^{k=2020}]$$

Local quarterly average

The average local temperatures obtained during quarters 1, 2, 3 and 4, for the year 2011 only, will be respectively noted as $MT_{loc1}^{k=2011}, MT_{loc2}^{k=2011}, MT_{loc3}^{k=2011}, MT_{loc4}^{k=2011}$ and calculated as :

$$MT_{loc1}^{k=2011} = \frac{\sum_{i=1...3} M_i^k}{3}, MT_{loc2}^{k=2011} = \frac{\sum_{i=4...6} M_i^k}{3}, MT_{loc3}^{k=2011} = \frac{\sum_{i=7...9} M_i^k}{3},$$

$$MT_{loc4}^{k=2011} = \frac{\sum_{i=10...12} M_i^k}{3},$$

The vectors corresponding to the period from 2011 to 2020 will be expressed as :

$$MT_{loc1}^{k=2011...2020} = [MT_{loc1}^{k=2011}, MT_{loc1}^{k=2012}, \dots, MT_{loc1}^{k=2019}, MT_{loc1}^{k=2020}];$$

$$MT_{loc2}^{k=2011...2020} = [MT_{loc2}^{k=2011}, MT_{loc2}^{k=2012}, \dots, MT_{loc2}^{k=2019}, MT_{loc2}^{k=2020}];$$

$$MT_{loc3}^{k=2011...2020} = [MT_{loc3}^{k=2011}, MT_{loc3}^{k=2012}, \dots, MT_{loc3}^{k=2019}, MT_{loc3}^{k=2020}];$$

$$MT_{loc4}^{k=2011...2020} = [MT_{loc4}^{k=2011}, MT_{loc4}^{k=2012}, \dots, MT_{loc4}^{k=2019}, MT_{loc4}^{k=2020}].$$

Overall quarterly average

The average local temperatures obtained, for 2011 only, will be noted $MT_{glob1...4}^{k=2011}$ and calculated as follows :

$$MT_{glob1...4}^{k=2011} = \text{mean}(MT_{loc1}^{k=2011}, MT_{loc2}^{k=2011}, MT_{loc3}^{k=2011}, MT_{loc4}^{k=2011}),$$

The vector corresponding to the period from 2011 to 2020 will have the expression :

$$MT_{glob1...4}^{k=2011...2020} = [MT_{glob1...4}^{k=2011}, MT_{glob1...4}^{k=2012}, \dots, MT_{glob1...4}^{k=2019}, MT_{glob1...4}^{k=2020}]$$

Seasonal average 1 local

The average local temperatures obtained during the long dry season, the short dry season, the long rainy season and the short rainy season, for 2011 only, will be respectively noted as $MS1_{loc1}^{k=2011}, MS1_{loc2}^{k=2011}, MS1_{loc3}^{k=2011}, MS1_{loc4}^{k=2011}$ and calculated as :

$$MS1_{loc1}^{k=2011} = \frac{\sum_{i=6...8} M_i^k}{3}, MS1_{loc2}^{k=2011} = \frac{\sum_{i=12,1,2} M_i^k}{3}, MS1_{loc3}^{k=2011} = \frac{\sum_{i=9...11} M_i^k}{3},$$

$$MS1_{loc4}^{k=2011} = \frac{\sum_{i=3...4} M_i^k}{3}$$

The vectors corresponding to the period from 2011 to 2020 will be expressed as :

$$MS1_{loc1}^{k=2011...2020} = [MS1_{loc1}^{k=2011}, MS1_{loc1}^{k=2012}, \dots, MS1_{loc1}^{k=2019}, MS1_{loc1}^{k=2020}];$$

$$MS1_{loc2}^{k=2011...2020} = [MS1_{loc2}^{k=2011}, MS1_{loc2}^{k=2012}, \dots, MS1_{loc2}^{k=2019}, MS1_{loc2}^{k=2020}];$$

$$MS1_{loc3}^{k=2011...2020} = [MS1_{loc3}^{k=2011}, MS1_{loc3}^{k=2012}, \dots, MS1_{loc3}^{k=2019}, MS1_{loc3}^{k=2020}];$$

$$MS1_{loc4}^{k=2011...2020} = [MS1_{loc4}^{k=2011}, MS1_{loc4}^{k=2012}, \dots, MS1_{loc4}^{k=2019}, MS1_{loc4}^{k=2020}];$$

Seasonal average 1 overall

The average of local mean temperatures obtained during the long dry season, short dry season, long rainy season and short rainy season, for the year 2011 only, will be noted $MS1_{glob1...4}^{k=2011}$ and calculated as :

$$MS1_{glob1...4}^{k=2011} = \text{mean}(MS1_{loc1}^{k=2011}, MS1_{loc2}^{k=2011}, MS1_{loc3}^{k=2011}, MS1_{loc4}^{k=2011}),$$

The vector corresponding to the period from 2011 to 2020 will have the expression :

$$MS1_{glob1...4}^{k=2011...2020} = [MS1_{glob1...4}^{k=2011}, MS1_{glob1...4}^{k=2012}, \dots, MS1_{glob1...4}^{k=2019}, MS1_{glob1...4}^{k=2020}]$$

Seasonal average 1 bis overall

The average of local mean temperatures obtained during the long dry season, short dry season, long rainy season and short rainy season, for the year 2011 only, will be noted. $MS1bis_{glob1...2}^{k=2011}$. Similarly, the average of local mean temperatures obtained during the long dry season, short dry season, long rainy season and short rainy season, for 2011 only, will be noted. $MS1bis_{glob3...4}^{k=2011}$. These 2 variables will be calculated as :

$$MS1bis_{glob1...2}^{k=2011} = \text{mean}(MS1_{loc1}^{k=2011}, MS1_{loc2}^{k=2011}),$$

$$MS1bis_{glob3...4}^{k=2011} = \text{mean}(MS1_{loc3}^{k=2011}, MS1_{loc4}^{k=2011}).$$

The vectors corresponding to the period from 2011 to 2020 will be expressed as :

$$MS1bis_{glob1...2}^{k=2011...2020} = [MS1bis_{glob1...2}^{k=2011}, MS1bis_{glob1...2}^{k=2012}, \dots, MS1bis_{glob1...2}^{k=2019}, MS1bis_{glob1...2}^{k=2020}]$$

$$MS1bis_{glob3...4}^{k=2011...2020} = [MS1bis_{glob3...4}^{k=2011}, MS1bis_{glob3...4}^{k=2012}, \dots, MS1bis_{glob3...4}^{k=2019}, MS1bis_{glob3...4}^{k=2020}]$$

Seasonal average 2 local

The average local temperatures obtained during the dry and rainy seasons, for the year 2011 only, are respectively noted as $MS2_{glob1}^{k=2011}$ and $MS2_{glob2}^{k=2011}$ and calculated as :

$$MS2_{loc1}^{k=2011} = \frac{\sum_{i=9...11} M_i^k + \sum_{i=3...5} M_i^k}{6}, MS2_{loc2}^{k=2011} = \frac{\sum_{i=6...8} M_i^k + \sum_{i=12,1,2} M_i^k}{6}.$$

The vectors corresponding to the period from 2011 to 2020 will be expressed as :

$$MS2_{loc1}^{k=2011...2020} = [MS2_{loc1}^{k=2011}, MS2_{loc1}^{k=2012}, \dots, MS2_{loc1}^{k=2019}, MS2_{loc1}^{k=2020}];$$

$$MS2_{loc2}^{k=2011...2020} = [MS2_{loc2}^{k=2011}, MS2_{loc2}^{k=2012}, \dots, MS2_{loc2}^{k=2019}, MS2_{loc2}^{k=2020}];$$

Seasonal average 2 overall

The average of local mean temperatures obtained during the dry and rainy seasons, for the year 2011 only, will be noted $MS2_{glob1...2}^{k=2011}$ and calculated as follows :

$$MS2_{glob1...2}^{k=2011} = \text{mean}(MS2_{loc1}^{k=2011}, MS2_{loc2}^{k=2011})$$

The vectors corresponding to the period from 2011 to 2020 will be expressed as :

$$MS2_{glob1...2}^{k=2011...2020} = [MS2_{glob1...2}^{k=2011}, MS2_{glob1...2}^{k=2012}, \dots, MS2_{glob1...2}^{k=2019}, MS2_{glob1...2}^{k=2020}]$$

Ergonomics and Anthropometry in the Design of Doyo Leaf Fiber Softener Machine

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Keywords— *Ergonomic, anthropometry,
softener machine, ulap doyo.*

Abstract— *One of the production processes for making weaving from doyo leaf fiber is the process of softening the dry leaf fiber before it is spun into yarn. This softening process is done so that the dried leaf fibers become more flexible and elastic so they can be easily spun into yarn. One aspect of machine design is reviewing machine design from ergonomic factors so that the machines used by workers are safer and more comfortable. This study aims to design a doyo leaf fiber softener machine in terms of the ergonomics of the machine's products. The analysis used in this study is an ergonomic analysis using anthropometric data tables using the sex of adult women, aged 18-45 years with a size of 50 percentile, from the Indonesian ethnic group. The results of the analysis show that the ergonomic machine height for workers is 100 cm, with a width of 100 cm and a machine height of 70 cm. The contribution of this research is to provide a design and build of doyo leaf fiber softener machine to the softener machine manufacturing industry so that the machine becomes ergonomic for the safety and comfort of the user.*

I. INTRODUCTION

Doyo weaving is woven made from the leaves of the doyo plant (*Curliglia Latifolia*), which grows in the Kalimantan region and is commonly used as fashion and handicraft products. Doyo weaving comes from doyo leaf fiber which is processed into yarn. The yarn made from doyo leaf fiber has different characteristics from other thread materials such as cotton and silk [1,2]. As a handicraft of ancestral cultural heritage for people in the province of East Kalimantan in Indonesia, this typical weaving has been exhibited and sold to national and international markets [3]. Doyo weaving has long been known since the 17th century and has been done from generation to generation by the Dayak tribe in East Kalimantan Province, Indonesia.

Based on data from the industry and trade service in East Kalimantan Province, East Kalimantan, in 2019 there were more than 60 doyo weaving craftsmen who continued to produce. The increasing number of enthusiasts of this weaving makes doyo weaving craftsmen experience problems in fulfilling so many market needs. This is because the process of making doyo weaving is done manually by hand which takes a long time.

In general, the process of making doyo weaving can be seen in Figure 1. The process of making doyo weaving starts with taking fresh doyo leaves, then washing the leaves and taking the fiber by rinsing while combing it in river water and then drying it in the sun to dry [4]. Furthermore, after the leaf fibers become dry, the process of softening and spinning the dried doyo leaf fibers into yarn is carried out. This softening and spinning process

takes the longest of all processes, to become one spool of yarn takes 2 days.

After it becomes yarn, it is given a dye that can be obtained from natural dyes to produce patterned woven fabrics through the process of weaving into cloth using tools that are still manual using human power to produce attractive woven fabrics [5,6].



Fig 1. The Process of Making Doyo Woven Fabrics [7]

The production process of processing dried leaf fibers into yarn is a process that takes a long time to turn into yarn with a thickness of less than 2 mm. For this reason, techniques or methods are needed to speed up the production process in this section by using tools in the process of making yarn. One of these processes is the process of softening the dry fiber of doyo leaves. This process is necessary so that the dried doyo leaf fibers become softer and more elastic before being spun into yarn. So it is necessary to design a machine that can help the efficiency and effectiveness of the production process of softening doyo leaf fibers into woven threads that still have the same quality.

This machine is specifically designed for doyo leaf fibers which have a stronger character and have more flexible properties than silk or cotton based threads. In designing this softener machine one of the main factors in designing the machine is the factor of safety and comfort when using this machine. To design an ergonomic doyo fiber softener machine, the analysis that will be applied in this study is an ergonomics analysis using anthropometric data as a basis for determining ergonomic machine sizes.

Ergonomics as a science that discusses user safety and comfort as interactions between humans and machines is a

necessity in developing product designs today. One area of ergonomics that focuses on discussing product sizes that are safe and comfortable when used is anthropometry [8,9]. Anthropometry discusses the dimensions of the human body which are recorded based on age, gender, ethnicity, type and job position as a basis for making the size of a product or machine according to its user [10,11,12].

Anthropometry is the measurement of the human body that can be used as a basis for determining the size of the minimum or maximum limits of products, equipment or ergonomic machines based on ethnicity, gender, disability, body position and posture during activities, as well as the type of work performed [13,14,15].

II. OBJECTIVES

This study aims to design a doyo leaf fiber softener machine with a review from the ergonomics point of view of the machine product. The contribution of this research is to provide a design of doyo leaf fiber softening machine to the softener machine manufacturing industry so that the machine becomes ergonomic for the safety and comfort of the user.

III. METHODOLOGY

Ergonomic doyo leaf fiber softener machine design design, then the analysis used is ergonomics analysis using anthropometric data tables. The anthropometric data used is anthropometric data adjusted to the worker.

The anthropometric data used as the basis for determining the size of the machine uses the sex of an adult female, aged 18-45 years with an average size of the 50th percentile adult female, from the Indonesian ethnic group. Data obtained from Indonesian anthropometric data [16].

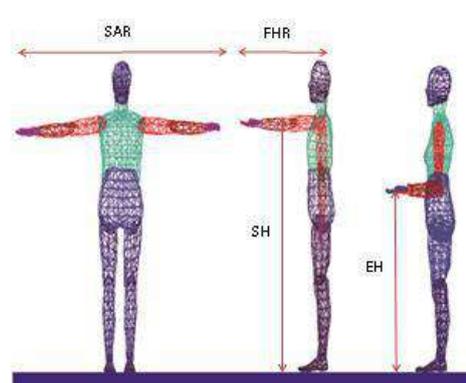


Fig 2. Anthropometric data

The data to be used are shoulder height, forward arm reach, side arm span, and elbow height. The figure 2 is the anthropometric data that will be used in this study.

The data to be used are shoulder height, forward arm reach, side arm span, and elbow height. The figure 2 is the anthropometric data that will be used in this study.

IV. RESULTS AND DISCUSSION

To design an ergonomic softener machine, the thing that must be considered first is to determine what kind of work the worker will do later. For the work of the doyo leaf fiber softening process, this is the type of work that is done while standing. The standing position in this process is so that workers can see better at the softening process of doyo leaf fibers. For this reason, the machine that is designed must have a height below the eye of the worker.

For the height of the machine, data from the anthropometric table of shoulder height of Indonesian adult women is used, which has an average height or 50 percentile. From anthropometric data, the shoulder height (SH) when standing for an adult woman aged 18-45 years is 129.74 cm. the data in this anthropometric table is data for the maximum size for machine height. In designing this machine the machine height used is 100 cm. This height is adjusted to the needs and comfort of workers when operating the machine and watching the machine grinding process in softening the dry fiber from doyo leaves.

The width of the machine is designed so that workers can reach the end of the machine while standing without difficulty. The width of the machine is based on anthropometric data from the forehead reach (FHR).

From Indonesian anthropometric data, it is found that the reach of the hand forward for Indonesian women is on average 71.13 cm, this size is the maximum width of the machine. Furthermore, in designing this machine, the width of the machine is 70 cm of the arm to the side (SAR). The data in the Indonesian anthropometric table is 154.87 cm. To make the machine more ergonomic and aesthetic, the width of the machine designed is 100 cm so that it is not too long.

The length of this machine still pays attention so that the machine works well, is safe and comfortable for workers. For the ergonomics of the machine, the main system of the machine and the construction of the machine frame are inside the machine casing to provide worker safety when operating the machine. Figure 3 and 4 is a prototype of the dry doyo leaf fiber softener machine designed in this study.



Fig 3. Prototype machine front view

The switch button to turn on and turn off the machine and the emergency button to stop the machine work are designed to be within reach of the worker's hands. The design of this button is positioned so that it is easily visible and uses a striking color. The colors used on the machine casing are bright colors that look more aesthetically pleasing. The design of this machine is made in a box shape to make it easier to move the machine.

The material input process in the form of dry doyo leaf fiber enters through a door that can be opened and closed again with the door positioned above the machine.

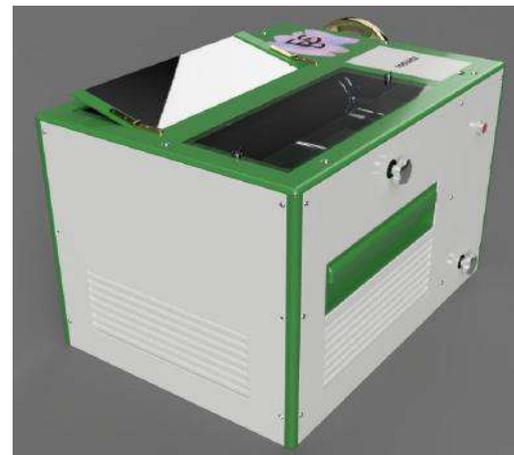


Fig 4. Prototype machine perspective view

This machine is also equipped with a transparent door cover so that workers can see from above the work process of softening doyo leaf fibers from above so that the eyes are not exposed to loose and flying particles when the machine is softening. After the production process is complete, the result is doyo leaf fiber which is soft and

ready to be spun into yarn which can be picked up at the front of the machine.

V. CONCLUSION

One of the production processes for making weaving from doyo leaf fiber is the process of softening the dried leaf fiber before it is spun into yarn. This softening process is done so that the dried leaf fibers become more flexible and elastic so they can be easily spun into yarn. This machine is specifically designed for doyo leaf fiber which has a stronger character and has more flexible properties than silk or cotton-based threads.

From the results of the analysis it was found that the ergonomic machine height for workers is 100 cm, with a width of 100 cm and a machine height of 70 cm. This machine is designed with a box shape that has a bright color. This machine has a transparent cover on it so workers can see the machine work directly.

Besides that, the placement of the switch button to turn on and turn off the machine and the emergency button is placed on the front of the machine which is easily accessible by workers with a striking color. It is hoped that this doyo leaf fiber softener machine can facilitate and provide safety and comfort to workers.

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REFERENCES

- [1] Kriya Kubar, Sekretariat Dekranasda Kabupaten Kutai Barat, Kalimantan Timur, Edisi Pertama Hut Kubar ke-17, 2016.
- [2] Buku Profil Serat Doyo, Disperindagkop dan UMKM, Provinsi Kaltim, 2014.
- [3] Atmoko Tri, Gunawan Wawan, Emilia Fransisca, Mukhlisi, Prayana Angga, & Arifin Zainal, Budaya Masyarakat Dayak Benuaq dan Potensi Flora Hutan Lembonah, Balai Penelitian Teknologi Konversi Sumber Daya Alam, November 2016.
- [4] Indriastuti Herning, Ulap Doyo : Produk Regiosentris Kalimantan Timur, JP Publishing. Sidowarjo. Jawa Timur, 2021.
- [5] Purbasari Mita, & Rahardja Anita, "Warna Tenun Doyo Sebagai Ekspresi Masyarakatnya (Tanjung Isuy-Kutai Barat)", Dimensi, Vol.14, No.2, Feb 2018.

- [6] Meilita, Yuwono Elisabeth Christine, & Yusuf Vanessa, "Perancangan Strategi Promosi Kain Tenun Ulap Doyo Pemayuq", Jurnal DKV Adiwarna, Vol 1, No 16, 2020.
- [7] Cahyadi Dwi, Suparno, Wulaningrum Ratna, Rojiki Imam, "Doyo Weaving Production Process as A Culture Herutage in East Kalimantan, Indonesia", International Journal of Engineering Technology Research & Management, Vol 06, Issue 07, July 2022.
- [8] Nurmianto, E. Ergonomi Konsep Dasar dan Aplikasinya, Guna Widya, 1998.
- [9] Letho M & Landry, S. J. Introduction to Human Factors and Ergonomics For Engineering, CRC Press, 2013.
- [10] Lee, Y., Kim, Y. M., Lee, J. H. & Yun, M. H, "Anthropometric mismatch between furniture height and anthropometric measurement: A case study of Korean primary schools", International Journal of Industrial Ergonomics, 68, 260-269, 2018.
- [11] Wang, C. Y. & CAI, D. C., "Hand tool handle size and shape determination based on hand measurements using a contour gauge", Human Factors and Ergonomics in Manufacturing & Service Industries, 30, 349-364, 2014.
- [12] Cahyadi, D., Fibriani, E., Irwan, M., Susandari, H. & Tantrika, C. F. M, "Design of workstation in the home industry of Amplang crackers production", iCAST-ES, Journal of Physics: Conference Series, 2019.
- [13] Adnan, N. & Dawal, S. Z. M, "Applied anthropometric for wheelchair user in Malaysia", Measurement, 136, 786-794, 2019
- [14] Lee, W., Yang, X., Jung, D., Park, S., Kim, H. & You, H. "Ergonomic evaluation of pilot oxygen mask designs", Appl Ergon, 67, 133-141, 2018.
- [15] Cahyadi, D, Aplikasi Mannequin Pro Untuk Desain Industri Leutikaprio, 2014.
- [16] Antropometri Indonesia, Available: <https://antropometriindonesia.org> [Accessed 17 Mei 2023], 2023.

Playfulness in early childhood education

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Keywords— *Playful, Early Childhood
Education, Mediator.*

Abstract— *The present work had as a line of research "The ludic in early childhood education" as a general objective to show the work of teachers in early childhood education regarding playfulness, such as playing and developing and the activities developed in municipal schools in Porto Nacional - TO , in the morning period of the pre-school that serves students aged between four and six years old. Twenty-three teachers collaborated for the field research in three schools. This research had a qualitative approach, with a descriptive and explanatory nature. In the first moment, there were collections of data obtained based on the application of the questionnaire, and the second part was to tabulate the data, generate the graphs and obtain the results and discussion. It is concluded that the tasks developed in the classroom regarding the ludic is valued by the pedagogues, they are specific methods, activities developed in the educational space are necessary for the student's reality and for the pedagogue who is as a mediator. The analysis of the results indicates that the teachers, in turn, work with the games, but the lack of adequate spaces makes the ludic pedagogical practices unsatisfactory.*

I. INTRODUCTION

This article is about the role of playfulness in early childhood education, and the relevance of working a didactic rich in games within the educational environment, for a satisfactory development.

For Silva (2021, p.7) "playing develops an important educational role in early childhood education. Through play, children develop, getting to know themselves" [...]. It can be said that playfulness is a tool of great value to be used in early childhood education, because games and games help in the development of the student.

The playfulness has as main teaching strategy, seek to unravel the world that involves the creativity of the child. The playful provides students with feelings of pleasure, emotions, joy, increasing your potential through the games. In addition to working on the affective, physical, cognitive aspects and especially the socialization between them.

According to Silva (2021, p.5), "the act of playing that helps the development of the child in its various aspects,

since through playing the child acquires and builds knowledge" [...]. From this reflection, it is stated that the playful is essential for the development of a child in the cognitive and physical part.

Thus, emphasizing the value of the professional before your didactic to better serve children in the early years, this research occurred with main.

However, the playful in the school space has a purpose of great value, because this tool brings students a learning of pleasurable way, because they learn by playing, and for a child the play is paramount, because through the toys and fun activities the child becomes creative and full of imaginations.

Therefore, this work had as general objective to understand that the playful is an important method for children in early childhood education in your learning practice. As specific objectives; identify the function of the playful: know the value of use in the room as a learning method, address educational actions that allows the playfulness.

II. MATERIAL AND METHODS

For Silva, p.114, addresses the research in the field, according to the data collected. Given this, the same data were used using a qualitative approach, descriptive explanatory nature, through which it was intended to analyze the conceptions of teachers about playing, more specifically in early childhood education, when programming their activities. In the first stage, a structured questionnaire was applied to teachers to verify the forms and purpose that games, toys and games assume in the pedagogical activity of Early Childhood Education. For the survey of these data were chosen 03 (three) schools of the municipal public education network in Porto Nacional -TO, in which worked 23 teachers, in the afternoon. Forms were applied, all questions and answers being individual.

The data collected in the questionnaire were classified into two parts: Demographic data, in which the research subject was characterized, place of work, training course and working time. Data from the reports and statements, finally, from the teachers' speeches about play in Early Childhood Education. It was characterized the frequency of playful activities, the purpose with which they were used and the criteria of choice related to the space they occupy in the classroom.

The receptivity of the educators of the school, considered as a whole, was of great value for the work to be carried out, since the teachers, for the most part, worked two periods a day, that is, while they were at school, they hardly had free time to answer the questionnaires and carry out other activities. Sometimes, the questionnaire was not answered on the same day due to the teacher's lack of time.

Teachers' available time outside the classroom was allocated to their daily planning routines, and the same time was used to answer the questionnaire. However, counting on the goodwill of the teachers and the rest of the professionals working at the school, it was possible to collect the necessary information. The categorization and tabulation of the data obtained were carried out by means of content analysis, and the frequency percentages were calculated from the total number of responses explained and not from the number of teachers.

The first step is to describe the data obtained from the application of the questionnaire. The twelve questions were asked to teachers who instructs in early childhood education of the municipal network, addressing concepts about the play and games and their use in the classroom.

The second step is to tabulate the data, generate the graphs, and then obtain the results and discussion.

III. RESULTS AND DISCUSSION

This chapter describes the data obtained in the application of the questionnaire to the teachers of the municipal network of early childhood education of Porto Nacional.

STEP ONE – QUESTIONNAIRE DATA

Training Course of the Teachers Surveyed

In the data obtained, there was a result of the training course of 83.40% who have a degree in Pedagogy and 16.60% who do not have a degree, as shown in figure 1.

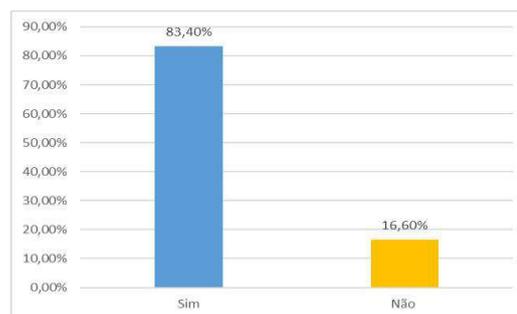


Fig. 1: Teacher training course

According to Brazil (2023), among teachers working in the initial years of primary education, 85.3% have a degree. In the final years, of the 753 thousand registered teachers, 91.8% have a higher education degree. In this stage, there was an increase of 6.6% of teachers with higher education in licentiate, in the period from 2016 to 2020.

In view of the above, the percentages of graduated teachers are increasing, with this bringing good news because there is a significant increase in teachers' schooling and postgraduate studies. In view of this statement, according to Brazil, the goal of the National Education Plan is that 50% of trained mediators of basic education have a postgraduate degree and continued graduation.

Another Course You Consider Important

Through the survey was directed the question if they were not pedagogues which profession they would have as training. 17% chose not to answer, 8% says he would like to practice medicine, 8% opted for administration, 8% biology, 25% would like to do postgraduate studies and 34% letters, as shown in figure 2.

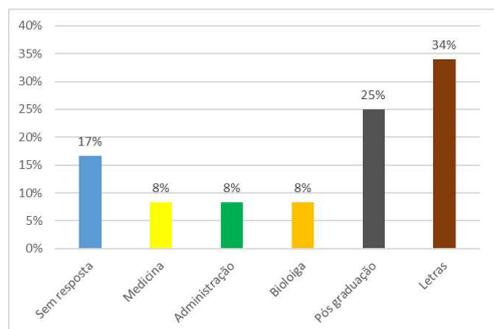


Fig. 2: Other courses you consider important

According to Scielo/Brazil (2018, n.p)

“Likewise, we realize that higher education also has gaps in relation to the formation of the reader of literature, a fact that compromises the entire reading network, considering that it is the responsibility of the Pedagogy course to train future teachers of children, young people and adults of the first levels of education.”

When analyzing the research data, it is a fact to say that the pedagogues who act directly and indirectly within the classroom most present difficulties in acting in the development of their pedagogical tasks for lack of specialization in the area and with this ends up compromising the entire learning process. Considering that through the research done in the institutions cited above, it is evident that the teachers who work in front of the classroom in turn made clear a negative point as a pedagogue, because most would like to work in other specializations performances.

How Long You Have Worked in Early Childhood Education

According to the result, it was evident that, 17% works with early childhood education less than 1 year and a half, 17% 1 year to 3 years, 8% 3 to 5 years, 8% 10 to 15 years, 42% more than 15 years, as shown in figure 3.

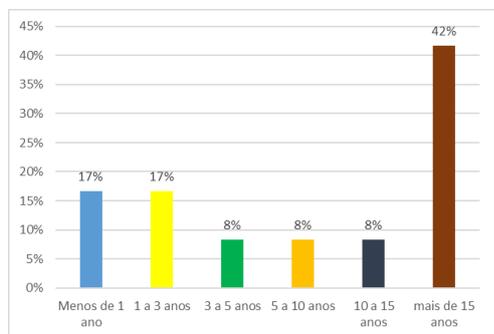


Fig. 3: Time working with early childhood education

According to Batista and Cardoso (2021, n.p)

“Teachers should also seek to deepen their understanding of the theories that underpin teaching and

learning practices. This can be achieved by reading about teaching and learning, regularly attending seminars and workshops, and enrolling in methodology courses that will enable them to rebuild their knowledge of the background to learning and teaching.”

According to the authors, every educator should strengthen his ability to deliver a good lesson, because each time he puts it into practice, he becomes more agile in his educational activities. In the results above, it shows that many pedagogues have already been working within the school environment, in this way the educator gains confidence in his teaching practices so that he can transmit to his students. Work the playfulness is to transmit experiences, creativity, fantasies, all together, and in this way the playful becomes a tool so important for children's education.

According to Batista and Cardoso (2021, n.p)

“While teacher training addresses the most "trainable" aspects of teaching based on knowledge and skills, teacher development is concerned with generating changes in relation to the most complex components of teaching, that is, awareness and attitude.”

Given this, it is important that every educator has training so that he has the ability and commitment to develop his satisfactory lesson plan for those who are there. The student, is the main factor for the educated, because he is the transmitter of knowledge, the one who generates motivation, qualified learning and transmits experiences that motivate the student to new teaching practices.

Numbers of Pupils in The Class

Given the number of students in the class, there was a result of 175 male students (57%) and 133 female students (43%), as shown in figure 4.

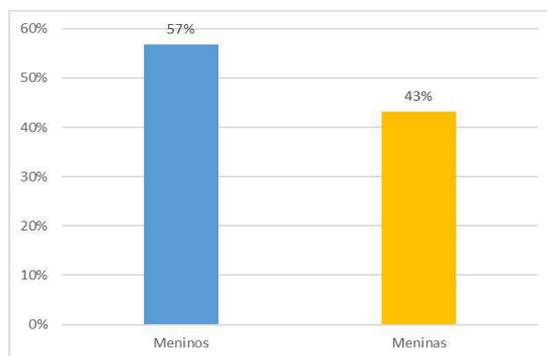


Fig. 4: Numbers of Pupils in The Class

For Lucena (2020, n.p)

“In CEIs (Early Childhood Education Centers), which receive children from 0 to 3 years old, the proposal sets different limits. Nurseries, for example, must have one

teacher for up to four babies. In daycare rooms, with children from 3 years old, the limit is ten students per teacher.”

In Elementary School I and II, the established limit is one teacher for up to 20 children.

In view of the studies done, it was notorious to see that the classrooms are compromised by too many students, causing difficulty in learning and often failing to use the playful, even with the projects that limits numbers of students per room, on the other hand is never done as mentioned above.

Weekly Working Hours in Early Childhood Education

According to the survey results, the working hours of these teachers were 8% 24 hours, 50% 30 hours, and 42% 40 hours, as shown in Figure 5.

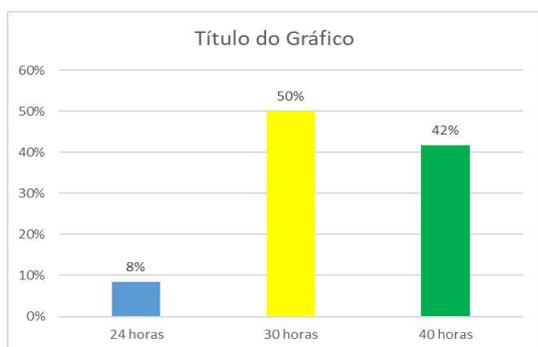


Fig. 5: Weekly Working Hours in Early Childhood Education

For Reino (2022, n.p) states that "The floor law, used for public school teachers, establishes that educators have a workload of 40 hours per week". Thus, it is clear that teachers working in public networks cannot accumulate workloads that exceed what is established by law.

STEP TWO - QUESTIONNAIRE DATA

Considers the Physical Space of the Classroom to be Adequate.

The question refers to the structuring of the environment and space, how the materials are organized, if there is quality, if they are used correctly. Since, they are essential tools of an educational plan for this teaching.

In fact, the classroom is an educational space that facilitates the child's knowledge process, in addition to providing an education it has as main objective to make a learning connection that makes students more able to face difficulties encountered in the class.

According to figure 6, the teachers' responses were informed, where it lists how the physical space is appropriate for students.

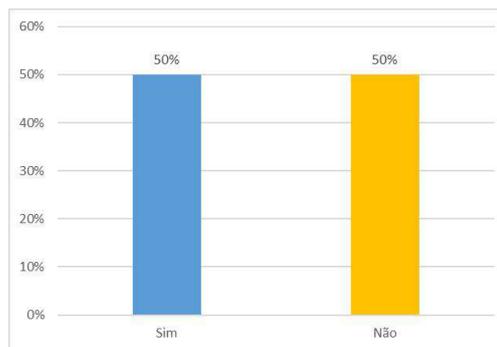


Fig. 6: Considers the Physical Space of the Classroom to be Adequate

As the graph 6 points out, it can be observed that of the twenty-three teachers interviewed, 50% think that the classroom of their school is adequate, emphasizing that the space is wide, and multifunctional, so there may be modifications to adapt the children to develop pedagogical actions. It is emphasized that 50% stated that the space is small, unfavorable to work activities in groups. In view of this, it also states that due to the lack of bathrooms inside the classroom, the personal use of children leaves something to be desired for both teachers and students.

According to the BNCC (Brazil, 2018)

Therefore, it is necessary that the spaces are urgently reframed, in order to ensure that children can play, investigate, run, research, because the more playful, careful, welcoming, purposeful and challenging the educational environment is, the greater the child's development will be.

In view of this, it is of great value that the space is adapted according to the student's precision so that it has an inclusive inteaction between them, through play the teacher makes adaptation in his pedagogical planning in order to satisfy the negative points that each student brings in the face of his school reality, and after all, the educator contributes and assists students in their learning and development making students confident and thus providing actions that stimulate their process.

Thus it is evident that through the field research contastou that the playfulness makes it necessary to work in school, however, in some institutions are not favorable to work within the school environment, because it does not have enough space to be used and so in most educators work the playfulness in other spaces not favorable.

Frequency You Use Playfulness in the Classroom

The data collected in the responses show that the frequency of use of the playful in the classroom every day is 92% and 8% reports that uses almost every day. Through the survey of the research shows that the

playfulness is essential in the activities in the classroom day by day, as shown in figure 7.

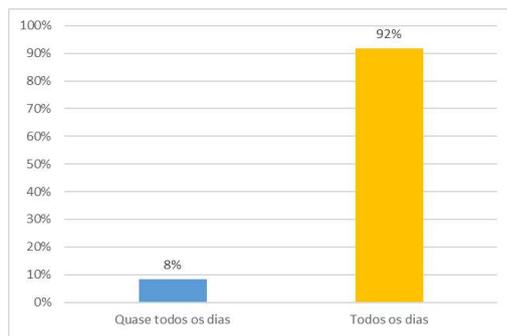


Fig. 7: Frequency You Use Playfulness in the Classroom

For Dionizio and Kiya (2014 p.6)

“Given this reality, in the search for alternatives to make teaching enjoyable for both students and teachers, the use of games and other playful activities, as pedagogical resources, can be the way out to improve the teaching and learning process making the educational work carried out in our schools more dynamic and enjoyable.”

In the speech of the authors, states that every teaching method in the early years will be favorable to work the playful, because the child is evolving and the application of playfulness before the reality of them helps in the cognitive process, motor coordination and among others.

In view of the research carried out in the Municipal fields it was evident that teachers use almost every day the playful even being unsatisfactory the size of the rooms where it hinders 100% the use of the playful.

Performs Games That Do Not Have Material

It is relevant to emphasize that the playful worked in the classroom assists in the child's learning, facilitating their development.

As for this question, the data collected in the answers show that 83% reports that performs games that do not have materials, and 17% says it uses with appropriate materials. The games that do not have the use of the playful are: Statue, mime, dead/live, follow the master, wheel, music, parlenda, dance and blind snake. Thus, all of them have their purposes, being: balance and attention, agility, sense of direction, concentration, balance in the body, memory development, rhythms, synchronies and motor coordination, creativity and emotions, according to figure 8.

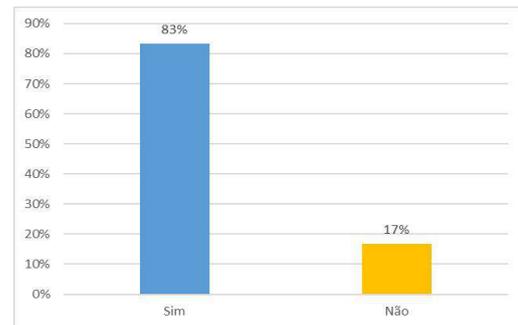


Fig. 8: Performs Games That Do Not Have Material

According to Kiya (2014, p.9)

“In the search for answers on how to make teaching enjoyable for both students and teachers we found that the use of games as well as playful activities, as methodological resources, can be the way out to improve the teaching/learning process and make the educational work carried out in our schools more dynamic and enjoyable.”

In this way, the pedagogue as the main role has the duty to include games games to have fun and learning. Given this, the use of recreational activities contributes to learning in addition to providing a pleasant class the mediator instigates the student to experience moments of pleasure and satisfaction and thereby contribute to a quality learning.

In view of the research carried out, the teachers show that the shortages that exist within the school environment are great, due to the lack of playful toys. Faced with this reality experienced in the classroom, the mediators use means of pedagogical activities so that the student learns the playful in a way that does not need toys, having as example: Statue, mime, dead/live, follow the master, wheel, music, parlenda, dance and blind snake. Another factor that makes it evident is that teachers use other spaces to work on playfulness, such as the sports court, the library, and others.

Time When Children Are Playing in the Classroom

Every mediator has a key role in the room, because with the intervention of the same makes a big difference to the child's learning.

According to the results obtained from the graph it was evident that 42% is observer, 50% mediator and 8% teacher, according to figure 9.

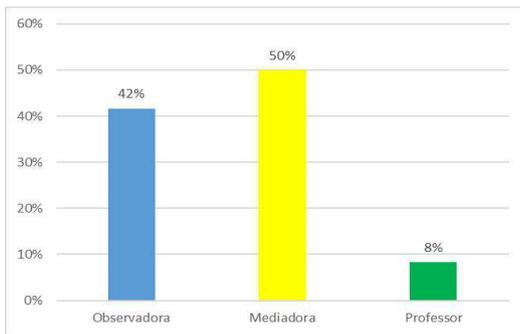


Fig. 9: Time When Children Are Playing in the Classroom

According to Kiya (2014, p.18) "for this activity to have a pedagogical nature and meet learning expectations, it is necessary for the teacher to observe some conditions that will contribute to the success of the event." Given this, for the activities to be developed in the class, it is necessary that the teacher knows his students, considering that he must make a planned pedagogical intervention, because the professional is in fact the transmitter of knowledge. Thus, for everything to go well and meet the expectations of the teaching offered, it is interesting that the teacher has attention and directs his students clearly and succinctly for his work to occur in a pleasant and satisfactory way.

Purpose That You Have Used or Often Use Activities Involving Play or Games to Teach

The playfulness is necessary in the adaptation in the teaching of the child, for this reason should use appropriate toys that arouse the interest of the child. Given this, each child has its stage for your learning, so it makes necessary these interventions using the playful method.

Before the survey, the games using the playful were: Bowling 17%, music 26%, bingo 8%, catch 8%, puzzle 8%, memory game 8%, hopscotch 8%, chair dance 17%. Having a result of 101%, as shown in Figure 10.

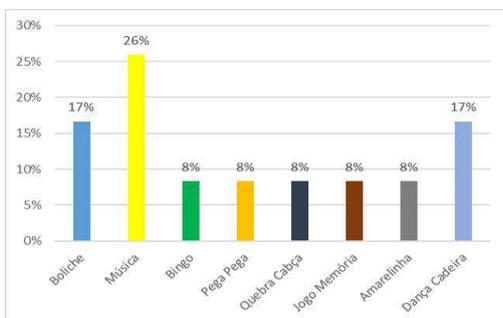


Fig. 10: Purpose That You Have Used or Often Use Activities Involving Play or Games to Teach

For Kiya (2014, p. 16)

“The use of games and games enables teachers to make their classes more dynamic, contributing to the learning to

occur spontaneously. Using the game properly, the teacher may have another strategy that will assist you in planning your classes.”

The games that involves the use of games have a direct relationship with the fun, so the mediator can be using various techniques for your planning of your classes, using methods that are able to convey a knowledge of excellence. It is worth mentioning that the teacher plays a very important role in the school context when he uses playfulness as a means of learning.

Introduction of Specific Materials for the Assembly of New Environments

According to the survey of that study, it is noted that the classroom should be conducive to the education of the child, being it cozy, environment to work in groups, socialization, moments of inclusion and thus all barriers be deconstructed.

Given the results, 42% makes use of the playful in the toy library, and 58% in the classroom, according to figure 11.

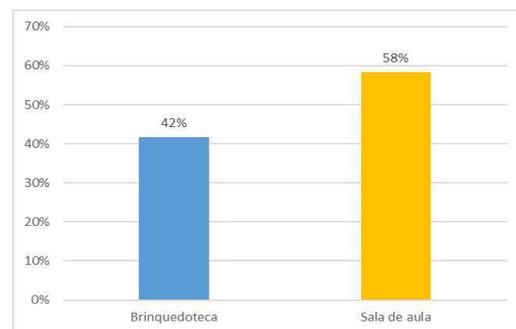


Fig. 11: Introduction of Specific Materials for the Assembly of New Environments

As Duarte and Mota (2021, n.p) points out, "Play can be an important ally for learning, since the child when playing make-believe, for example, represents different gender roles and diverse cultures." In this way, makes it visible that a child has a duty to play, because the playfulness becomes one of the main method to be used in the formation of learning. With this tool is able to work several roles as culture, so it will develop and become a tolerant citizen, knowing how to respect others. Another factor that is worth mentioning is that the school environment should be appropriate for the amusements of students containing a favorable environment and materials to introduce the contents so that there is a qualified learning.

IV. FINAL CONSIDERATION

By virtue of the facts mentioned the development process has great importance when it comes to playfulness

in the room, we sought to identify the ways that the mediator works the games in the room. From the field research, it was found that all the mediators surveyed at that time demonstrated that it makes use of the games in the room, even with the scarcity that the school spaces are. In this sense, it can be observed that the teachers of the municipal schools make it evident that the activities developed were of great importance and fundamental for the learning of the students.

Given this and fact that the playful in the early years is favorable in pedagogical practice because it brings respect, creativity, interaction, attention, reasoning, psychomotor and cognitive development, affective and respect between them in general. In view of all the research in the field, and considerable that the playful activities within the classroom are fundamental for children, since it is an essential pedagogical method and considered important for the student and teacher, where the mediator will transmit his knowledge in a positive and pleasurable way. It is relevant to emphasize that the playful methods in the room that the teacher makes available to the students also helps in the moments of inclusion, interaction between them and to contribute to their learning.

Therefore, it is concluded that teachers have a fundamental role in several moments in the child's daily life in playful pedagogical actions, contributing in a significant and pleasurable way. Thus the games is of great relevance to pedagogical educators, in which it is necessary that the spaces occur some changes where they need support to occur the playful activities and that children develop their activities without difficulties. I conclude that playing is a method that the child uses in the classroom, and that she learns while playing.

REFERENCES

- [1] Brazil, Ministry of Education. Research reveals an increase in the education of teachers. Brasília, DF: Ministry of Education, gov.br, March 2021. Available in: <https://www.gov.br/inep/pt-br/assuntos/noticias/censo-escolar/pesquisa-revela-aumento-de-escolaridade-dos-docentes> Accessed July 24, 2023 at 11:30 am.
- [2] Brazil. Ministry of Education. Common National Curriculum Base. The place of play in early childhood education. Brasília, 2018. Available at: <http://basenacionalcomum.mec.gov.br/implementacao/praticas/caderno-de-praticas/aprofundamentos/198-o-lugar-do-ludico-na-educacao-infantil> Accessed on: July 24, 2023 at 3:53 pm
- [3] Cardoso, M. D. O., & Batista, L. A. Early childhood education: the ludic in the process of formation of the individual and its specificities. Public Education Magazine, v. 21 No. 23, June 22, 2021. Available at: <https://educacaopublica.cecierj.edu.br/artigos/21/23/educaca>
[o-infantil-o-ludico-no-processo-de-formacao-do-individuo-e-suas-especificidades](https://educacaopublica.cecierj.edu.br/artigos/21/23/educacao-infantil-o-ludico-no-processo-de-formacao-do-individuo-e-suas-especificidades) Acesso em 24 julho 2023 às 15:00.
- [4] Dionizio, F, A, Q., & KIYA, M, C, da S. The use of games and recreational activities as a pedagogical resource that facilitates learning. Paraná: volume I 2014. Available at: http://www.diaadiaeducacao.pr.gov.br/portals/cadernospde/pdebusca/producoes_pde/2014/2014_uepg_ped_artigo_marcia_cristina_da_silveira_kiya.pdf. Access 24 July 2023 at 16:18
- [5] Duarte, J. R., & Mota, E. A. The ludic in the learning process in early childhood education. Public Education Magazine, v. 21 No. 15, April 27, 2021. Available at: <https://educacaopublica.cecierj.edu.br/artigos/21/15/o-ludico-no-processo-de-aprendizagem-na-educacao-infantil> . Accessed on: July 25, 2023, at 6:46 pm.
- [6] Reino, P. A. Complete guide on the teacher's working day. May 12, 2023. Available at: <https://arraesecenteno.com.br/guia-completo-sobre-a-jornada-de-trabalho-da-professora/#:~:text=A%20lei%20do%20pis%C3%A9rio%20de%2040%20horas%20semanais>. Access 24 July 2023 at 3:40 pm
- [7] Saldanha, D.M.L., & Amarilha, M. The teaching of literature in the pedagogy course: a necessary presence. Scielo Magazine, November 2018. Available at: https://www.scielo.br/j/er/a/MJOvVRfwvSxHnvF49dJLBRd/_/Access 24 July 2023 at 14:57.
- [8] Silva, A. P. L.,. The ludic in early childhood education: conceptions and practices of teachers in the municipal network of campo grande-ms. Campo Grande, MS - 2006. Available at: [file:///C:/Users/paulo/Downloads/7873-o-ludico-na-educacao-infantil-concepcoes-e-praticas-dos-professores-na-rede-municipal-de-campo-grande-ms%20\(4\).pdf](file:///C:/Users/paulo/Downloads/7873-o-ludico-na-educacao-infantil-concepcoes-e-praticas-dos-professores-na-rede-municipal-de-campo-grande-ms%20(4).pdf). Accessed on: February 22, 2023.
- [9] Silva, C. M. da., E-book with playful activities for early childhood education. Pub.2021. Available in: <https://repositorio.ivc.br/bitstream/handle/123456789/1091/Ebook-Cristiely2.pdf?sequence=1&isAllowed=y> Accessed on: February 22, 2023 at 5:47 pm.
- [10] São Paulo, City Council. Project limits number of students per classroom. Saopaulo.sp.leg, May 2020. Available at : <https://www.saopaulo.sp.leg.br/blog/projeto-limita-numero-de-alunos-por-sala-de-aula/#irmenu>. Accessed on July 24, 2023, at 3:17 pm.
- [11] Kiya, M. C. S. The use of games and recreational activities as a pedagogical resource that facilitates learning. Paraná, volume II 2014. Available at: [file:///C:/Users/paulo/Downloads/2014_uepg_ped_pdp_marcia_cristina_da_silveira_kiya%20\(1\).pdf](file:///C:/Users/paulo/Downloads/2014_uepg_ped_pdp_marcia_cristina_da_silveira_kiya%20(1).pdf) Accessed on July 25, 2023 at 6:32 pm

The Possibility of using Flared Gas to Generate Electricity using Combined Power Cycle

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Keywords— *Exergy, Power Cycle, Power, Rankine, Brayton, Gas Turbine, Steam Turbine*

Abstract— *This work evaluated the possibility of generating electricity from flared gases through the application of combined power cycle (Organic Rankine and Brayton circle) which was simulated using Aspen Hysys. The data for the stimulation was obtained from literature in terms of the process plant operating conditions. The results obtained from the simulation were presented in terms of material balance, energy balance, costing, sensitivity analysis and exergy analysis, which is otherwise known as energy availability. The major equipment in the plants were: pump, heat exchanger, compressor, combustion chamber (conversion reactor), and an expander modeled as a gas and steam turbine respectively in Aspen Hysys simulation. The condenser was modeled as a cooler. The material and balance results were in agreement with the principles of conservation of mass and energy for a steady state process. The costing of the plant in terms of total capital cost, total operating cost, total utility cost, equipment cost and total installation cost were: \$16,762,100.00, \$70,661,490.00, \$4,745,230.00, \$11,323,700.00 and \$12,359,400.00 correspondingly. The sensitivity analysis results revealed that efficiency of the gas turbine increase with an increase in exhaust gas pressure (kPa), signifying that the efficiency increased from 81.5% to 85% when the exhaust gas pressure was raised from 100 kPa to 500 kPa. The efficiency of the steam turbine increased from 72.6% to 74.2% when the outlet pressure was raised from 100 kPa to 900 kPa. Finally, the exergy result for gas turbine in terms of total exergy inlet and outlet are 14187 kW and 3710 kW respectively. This indicates an exergy efficiency of 26.15% or 10,477 kW exergy destruction. Similarly, the exergy result for steam turbine in terms of total exergy inlet and outlet are 1,856 kW and 1,357 kW respectively. This indicates an exergy efficiency of 73.12% or 498kW exergy destruction*

I. INTRODUCTION

A great deal of gas flaring at many oil and gas production sites has nothing to do with protection against the dangers of over-pressuring industrial plant equipment (Rahimpour *et al.*, 2012). When petroleum crude oil is extracted and

produced from onshore or offshore oil wells, raw natural gas associated with the oil is transported to the surface, as well. Mostly in the developing countries of the world where pipelines and other gas transportation infrastructure is not developed, vast amounts of such associated gases are commonly flared as waste or unusable gas.

Gas flaring flow measurement applications present several unique challenges to the Plant, Process and Instrument engineers when selecting a flow meter system. According to (Mohammad et al., 2015), there are many challenges, when trying to measure the gas flared, including diameters of large pipe, high flow velocities over wide measuring ranges, changing gas composition, low pressure, including dirt, wax and condensate. The procedure of flared gas measurement are uniquely challenged by two various and critically important flow conditions: very low flow under normal conditions and sudden very high flows during an upset blow-down conditions. Additionally, several other important criteria must be considered when selecting constraints and considering a flow meter for flared gas applications, such as: plant Operators, Managers, Process and Instrument engineers.

According to Orimoogunje & Odiong (2010), when petroleum crude oil is extracted and produced from oil wells, raw natural gas associated with the oil is brought to the surface as well. Especially in areas of the world lacking pipelines and other gas transportation infrastructure, vast amounts of such associated gas are commonly flared as waste or unusable gas. The flaring of associated gas may occur at the top of a vertical flare stack or it may occur at a ground-level flare in an earthen pit. The other option is gas re-injection into the reservoir, which saves it for future use while maintaining higher well pressure and crude oil productivity.

Eman (2015), defined gas flaring as the process of burning-off associated gas from wells, hydrocarbon processing plants or refineries, either as a means of disposal or as a safety measure to relieve pressure. It is now recognized as a major environmental problem. It contributes an amount of about 150 billion m³ of natural gas flared around the world, with the consequences of contaminating the environment with about 400 metric tons CO₂ per year.

Jones & Samuel (2021), stated that between 1990 to 2017 period, oil supply which formed a key part of the energy generation process in Ghana has increased from about 1,000 ktoe (kiloton of oil equivalent) to more than 3,000 ktoe.

Gas supply has also witnessed a steady growth since 2008, that is, over 1000 ktoe in 2017.

Saheed & Ezaina (2012) considered the impact of gas flaring is of local and global concern. Gas flaring is one of the most challenging energy and environmental problems facing the world today whether regionally or globally. It is a multi-billion dollar waste, a local environmental catastrophe and a global energy and environmental problem which has persisted for decades.

Azeez (2017), alluded that gas flaring is one of the major environmental problems in the world now. It consumes useful natural resources and produces harmful wastes, which have negative impacts on the society. It is one of the most tedious energy and environmental problems facing the world today.

Francis et al., (2022), lamented that Nigeria is a country blessed with vast oil and natural gas resources, but due to inadequate management of resources most of the natural gas is flared. One of the most pressing challenges today is global warming. Gas flaring has been known to produce carbon dioxide and other ozone depleting substances, which ultimately cause global weather changes.

II. PROCESS DESCRIPTION

Figures 1 and 2 depict process flow diagrams of the base case obtained from literature and the simulation case from Aspen Hysys software. In Figure 2, air is compressed in a compressor and the outlet of the compressor was reacted with flared gas inside a combustion reactor, where the reaction between air and flared gases takes place to produce carbon dioxide and water. The outlet product from the combustion reactor is fed to a steam turbine. The outlet of the steam turbine is then fed to a heat exchanger to complete the first circle known as Brayton circle. The next circle which is known as Rankine circle starts with the working fluid pumped into the heat exchanger where it is to be heated with the exhaust stream from the gas turbine. The (outlet) - the hot fluid from the heat exchanger is fed to the steam turbine where its outlet is cooled in a condenser and recycled back into the pump to complete the circle.

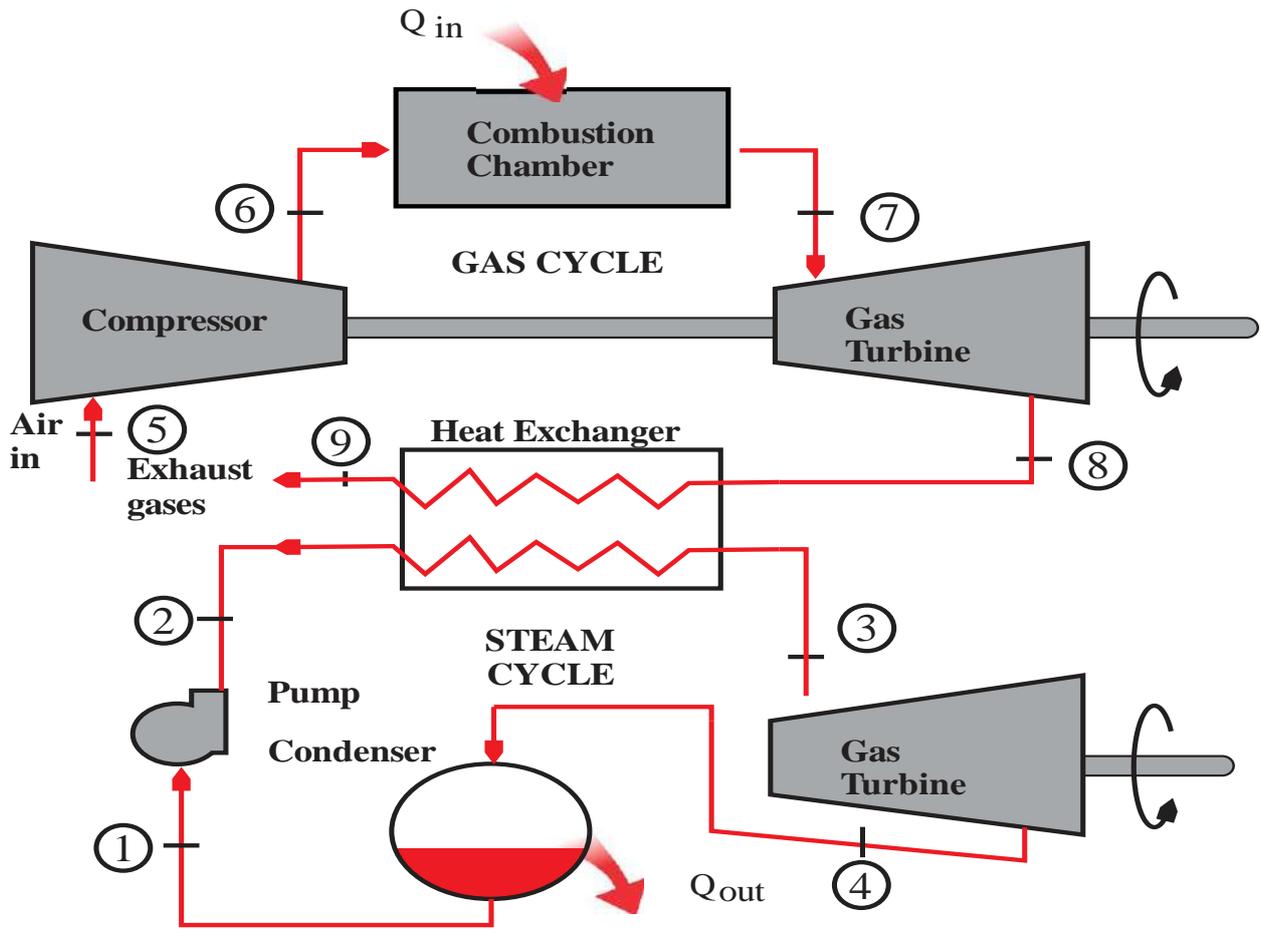


Fig.1. Base Case Combined Gas-Steam Plant (Yunus & Michael, 2006)

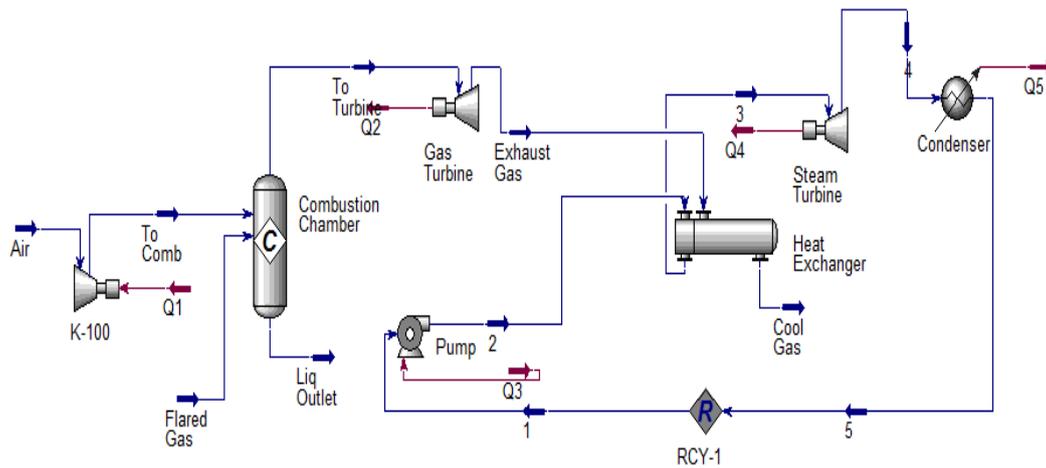


Fig.2. The Aspen Hysys Simulation Case of Combined Gas-Steam Plant

III. RESULTS AND DISCUSSION

The results obtained from the simulation of combined power plants (steam turbine and gas turbine are presented in Figures 3 to 8)

3.1 Effect of Gas Turbine Efficiency Changing with Outlet Pressure of Turbine

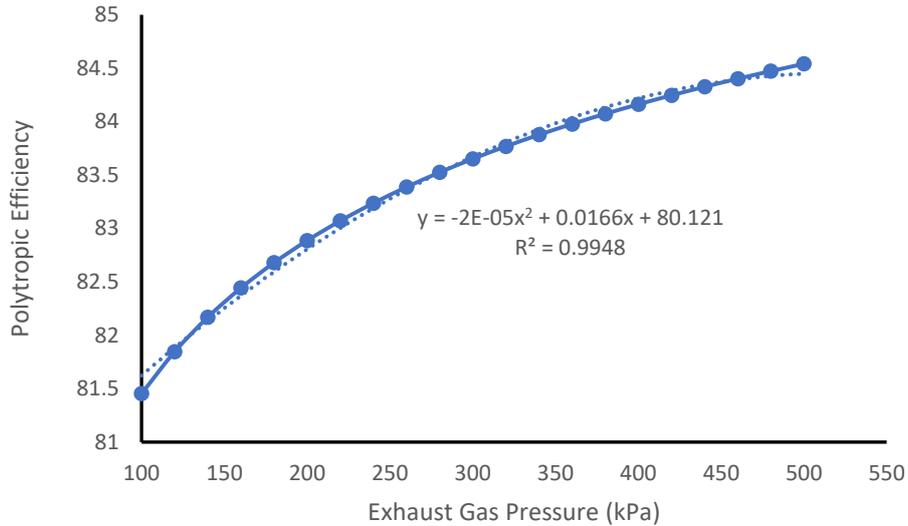


Fig.3: Profile Plot of Polytropic Efficiency of Gas Turbine versus Outlet Pressure of Turbine

Figure 3 shows how the increase in the outlet pressure of the turbine causes a corresponding increase its outlet pressure. Hence, from Figure 3, an increase in turbine’s outlet pressure from 100 kPa to 500 kPa causes its polytropic efficiency to increase from 81.5% to 85%. This means that, if optimization of the turbine efficiency is desired then the outlet pressure of the turbine should be increased until the desired efficiency is achieved. Care must be taken when increasing the outlet pressure of the turbine, because it might get out of range to achieve the desired

efficiency. Therefore, an alternative solution to this problem is to make use of the Adjust Function Tool (AFT) in Aspen Hysys, which is applied in sensitivity analysis. The technique to study the effect of change in input variables on the output of a process model. The results obtained from the sensitivity analysis can be used further to carry out process optimization.

3.2 The Effect of Gas Turbine Power Changing with Outlet Pressure of Turbine

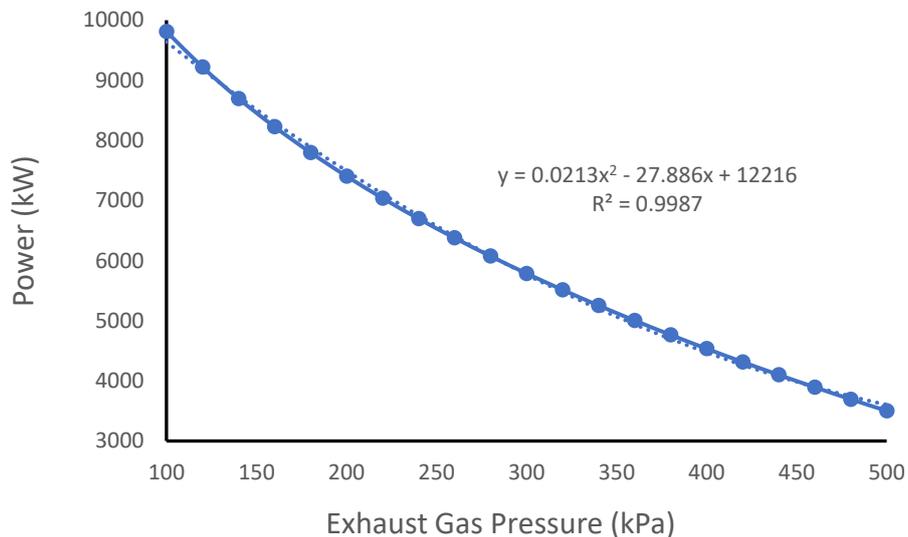


Fig.4. The Profile Plot of Polytropic Efficiency of Gas Turbine versus Outlet Pressure of Turbine

Figure 4 shows how the increase in the outlet pressure of the turbine causes a corresponding increase its power. Hence, from Figure 4, an increase in turbine’s outlet pressure from 100 kPa to 500 kPa causes its power to

decrease from 9000 kW to about 3000 kW. This means that, if optimization of the turbine power is desired, then the outlet pressure of the turbine should be decreased until the desired efficiency is achieved. Care must be taken when

decreasing the outlet pressure of the turbine, because it might get out of the range to achieve the desired efficiency. Therefore, an alternative solution to this problem is to make use of the AFT in Aspen Hysys which is applied in sensitivity analysis (the technique to study the effect of change in input variables on the output of a process model).

The results obtained from the sensitivity analysis can be used further to carry out process optimization.

3.3. The Effect of Gas Turbine Polytropic Head Changing with Air Mass Flow Rate

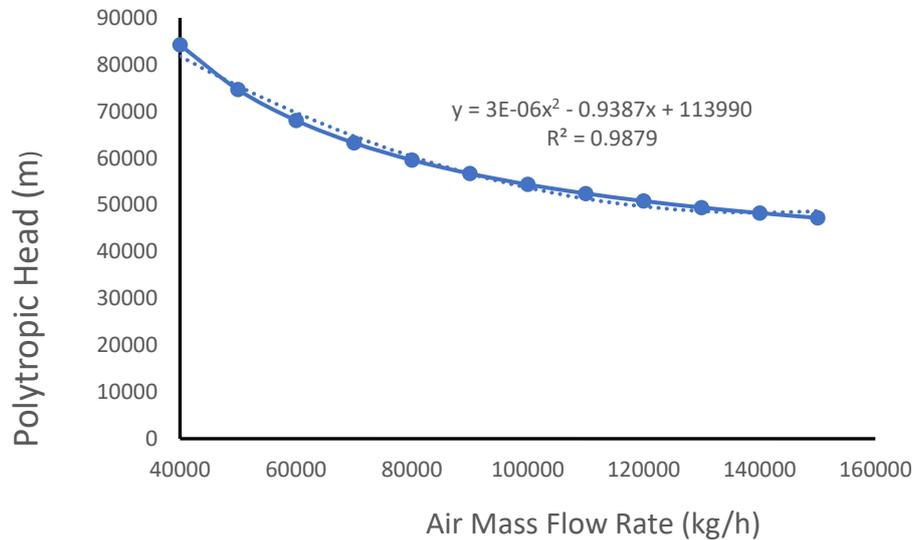


Fig.5. Profile Plot of Polytropic Head of Gas Turbine versus Air Mass Flow Rate

Figure 5 shows how the increase in the mass flow rate of air of the gas turbine causes a corresponding decrease its polytropic head. Hence from Figure 5, an increase in gas turbines air mass flow rate from 40,000 kg/h to 150,000 kg/h causes its polytropic head to decrease from 84,230 to 47,230 meters. This means that, if optimization of the gas turbine polytropic head is desired, then the air mass flow rate of the turbine should be adjusted until the desired efficiency is achieved. Care must be taken when adjusting the air mass flow rate of the gas turbine because it might get out of range to achieve the desired efficiency, therefore an AFT is used as an alternative solution to this problem as described above. The results obtained from the sensitivity analysis can be used further to carry out process optimization.

3.4. The Effect of Gas Turbine Polytropic Efficiency Changing with Air Mass Flow Rate

Figure 6 shows how the increase in the mass flow rate of air of the gas turbine causes a corresponding decrease its polytropic efficiency. Hence, from Figure 6, an increase in gas turbine’s air mass flow rate from 40,000kg/h to 150,000 kg/h causes its polytropic efficiency to decrease from 87.1% to 81.2% This means that, if optimization of the gas turbine’s polytropic efficiency is desired then the air mass flow rate of the turbine should be adjusted until the desired efficiency is achieved. Care must be taken when adjusting

the air mass flow rate of the gas turbine, because it might get out of range to achieve the desired efficiency, therefore an alternative solution is to use the AFT, ditto. The results obtained from the sensitivity analysis can be used further to carry out process optimization.

3.5. The Effect of Steam Turbine Efficiency Changing with Outlet Pressure of Turbine

Figure 7 shows how the increase in the outlet pressure of the steam turbine causes a corresponding increase its outlet pressure. Hence, from Figure 7 an increase in turbine’s outlet pressure from 100 kPa to 900 kPa causes its polytropic efficiency to increase from 72.6% to 74.2%. Which means that, if optimization of the steam turbine efficiency is desired then the outlet pressure of the turbine should be increased until the desired efficiency is achieved. Care must be taken when increasing the outlet pressure of the turbine, because it might get out of range to achieve the desired efficiency. As such, an alternative solution to this problem is to make use of the AFT, ditto. The results obtained from the sensitivity analysis can used further to carry out process optimization.

3.6 The Effect of Steam Turbine Power Changing with Outlet Pressure of Turbine

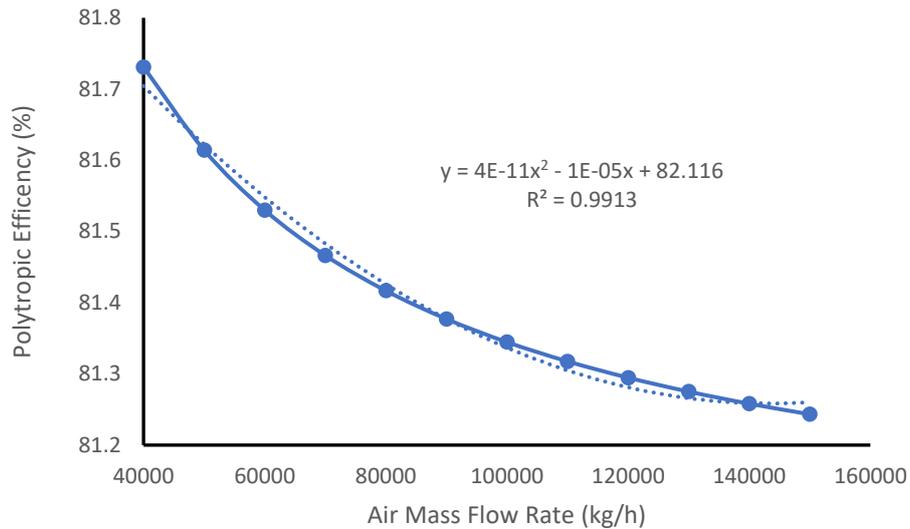


Fig.6. The Profile Plot of Polytopic Efficiency of Gas Turbine versus Air Mass Flow Rate

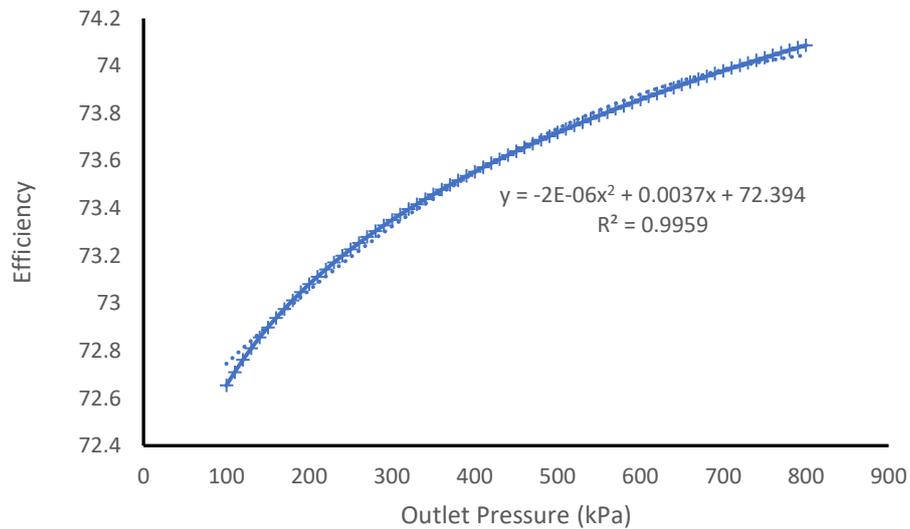


Fig.7. The Profile Plot of Polytopic Efficiency of Steam Turbine versus Outlet Pressure of Turbine

Figure 8 shows how the increase in the outlet pressure of the turbine causes a corresponding increase its power. Hence, from Figure 8, an increase in turbines’ outlet pressure from 100 kPa to 900 kPa causes its power to decrease from 800 kW to about 300 kW. This means that, if optimization of the turbine power is desired, then the outlet pressure of the steam turbine should be decreased until the desired efficiency is achieved. Care must be taken when decreasing the outlet pressure of the steam turbine, because it might get out of range to achieve the desired efficiency. Therefore an alternative solution to this problem is to make use of the AFT, ditto. The results obtained from the sensitivity analysis can used further to carry out process optimization.

From Figure 8, air was compressed in a compressor and the outlet of the compressor was reacted with flared gas inside a combustion reactor where the reaction between air and flared gases takes place to produce carbon dioxide and water. The outlet product from the combustion reactor is fed to a steam turbine. The outlet of the steam turbine is then fed to a heat exchanger to complete the first circle known as Brayton circle. The next circle which is known as Rankine circle starts with the working fluid pumped into the heat exchanger where it is to be heated with the exhaust stream from the gas turbine, the outlet of the hot fluid from the heat exchanger is fed to the steam turbine where its outlet is cooled in a condenser and recycled back into the pump to complete the circle.

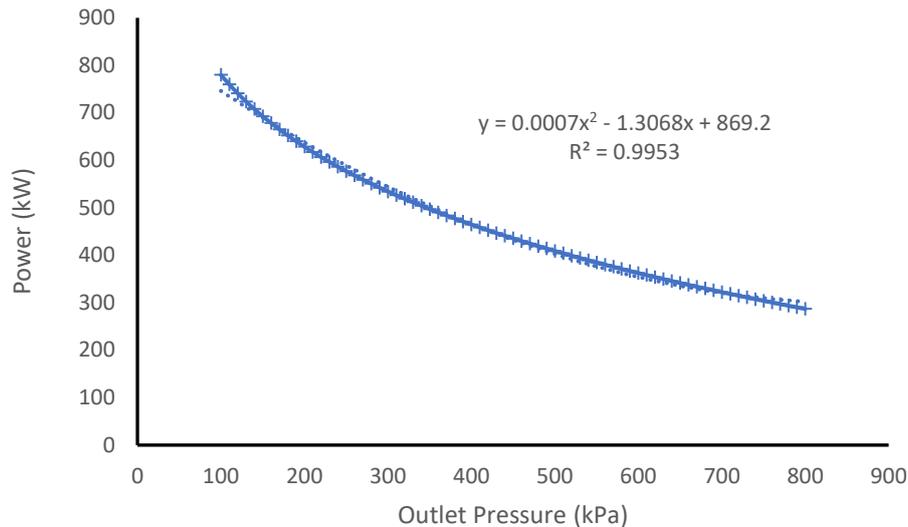


Fig.8. The Profile Plot of Polytropic Efficiency of Steam Turbine versus Outlet Pressure of Turbine

IV. CONCLUSION

From the foregoing, the following are the summary of the work:

- (i) The material balance results were in agreement with the principles of conservation of mass and energy for a steady state process.
- (ii) The costing of the plant in terms of total capital cost, total operating cost, total utility cost, equipment cost and total installation cost were: \$16,762,100.00, \$70,661,490.00, \$4,745,230.00, \$11,323,700.00 and \$12,359,400.00 correspondingly.
- (iii) The sensitivity analysis results revealed that efficiency of the gas turbine increased with an increase in exhaust gas pressure (kPa) signifying efficiency increase from 81.5% to 85% when exhaust gas pressure was raised from 100 kPa to 500 kPa. The efficiency of the steam turbine increased from 72.6% to 74.2% when the outlet pressure was raised from 100 kPa to 900 kPa. Finally, the exergy result for gas turbine in terms of total exergy inlet and outlet are 14,187 kW and 3,710 kW respectively. This indicates an exergy efficiency of 26.15% or 10,477 kW exergy destruction. Similarly, the exergy result for steam turbine in terms of total exergy inlet and outlet are 1856 kW and 1,357 kW respectively. This indicates an exergy efficiency of 73.12% or 498 kW exergy destruction.

REFERENCES

- [1] Orimoogunje, O. I., Ayanlade, A., Akinkuolie, T. A. & Odiong, A. U. (2010). "Perception on the effect of gas flaring on the environment," *Research Journal of Environmental and Earth Sciences*, 2(4), 188-193.
- [2] Yunus, C. & Michael, B. (2018). *Thermodynamics: An Engineering Approach* (8th Ed). Mc Graw Hill Education: London: UK.
- [3] Rahimpour, M.R., Jamshidnejad, Z., Jokar, S.M., Karimi, G., Ghorbani, A., & Mohammadi, A.H.(2012). A Comparative Study of three different Methods for Flare Gas Recovery of Asalooya Gas Refinery. *Journal of Natural Gas Science and Engineering*, 4, 17-28.
- [4] Mohammad, S., Angineh, Z., Mohammad, J.G. & Eugenia, K. (2015). A Review of Global Gas Flaring and Venting and Impact on the Environment: Case Study of Iron. *International Journal of Greenhouse Gas Control*, 49, 489-508.
- [5] Eman, A.E. (2015). Gas Flaring in Industry: An Overview. *Petroleum & Coal*, 57(5), 532-555.
- [6] Jones, L.A., Samuel, A.O. (2021). A Review of the Causes of Sustainable Supply Deficiencies in Natural Gas Supply in Ghana. *Journal of Power and Energy Engineering*, 9(1),1-20.
- [7] Ikebude, C.F.(2017). Feasibility Study on Solid Waste Management in Port Harcourt Metropolis: Causes, Effect and Possible Solutions. *Nigerian Journal of Technology*, 39(1), 12-29.
- [8] Saheed, O.I., & Ezaina, G.U. (2012). Global Impact of Gas Flaring. *Energy and Power Engineering*, 4(1), 290-302.
- [9] Azeez, G.A.(2017). Natural Gas Flaring: Alternative Solutions. *World Journal of Engineering and Technology*, 5(1), 139-153.
- [10] Francis, B.E., Chizitelu, I.N., Olayemi, B.O., & Feyisayo, D.I. (2022). Natural Gas Flaring in Nigeria, Its Effects and Potential Alternatives: A Review. *Journal of Ecological Engineering*, 23(8), 141-151.

A Fuzzy Robust Controller for Robotic Systems

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Keywords— Type-2 Fuzzy Systems,
Robust Control, Robotic system.

Abstract— In this work a combination of type 2 fuzzy logic and nonsingular fast sliding mode technique is proposed to design a robust controller for a robotic system. Indeed, a nominal type 2 fuzzy model is used to contract the equivalent control signal. The switching signal is designed using adaptive type 2 fuzzy systems to overcome the knowledge of the upper bounds of uncertainties and external disturbances. Several simulation results are given to show the efficiency of the proposed approach.

I. INTRODUCTION

Widely used in many applications, sliding mode control can be considered a very popular approach to ensure good tracking performances against external disturbances [1]. Despite its simple design procedure and good tracking performances, sliding mode control has two major disadvantages. The first one is the chattering phenomena introduced by using signum function in the control signal. The second disadvantage lies in its time convergence, which cannot impose. Several improvements have been proposed in the literature to reduce the chattering phenomena. In [2], the switching signal is smoothed by using a low-pass filter. An adaptive fuzzy system has been used in [3] to substitute the switching control and, hence, to eliminate the chattering phenomenon. However, this improvement needs a tradeoff between the smoothness of the switching signal and tracking performances. Second order sliding mode control have been also presented a good solution to chattering but the design procedure is complex and the requires a good knowledge of the studied system [4].

Recently, terminal sliding mode control have been developed, where a nonlinear surface is used [5-6]. However, these kinds of controllers suffer from singularity problem due to presence of terms with negative fractional

powers. This problem can be resolved by using a nonsingular terminal sliding mode controller [7-8]. Nevertheless, this improvement was obtained at the expense of the convergence time which becomes slower. Nonsingular fast terminal sliding mode controller have been developed to overcome singularity and to obtain fast convergence time [9]. Thus, in this paper, we propose a nonsingular fast terminal sliding mode controller for a robotic system which guarantees finite-time convergence, fast speed when the states are far from the origin, avoidance of singularity and without chattering. The control is developed using a fuzzy nominal model witch avoids using approximating system dynamics. Furthermore, adaptive type 2 fuzzy systems have been used to avoid a well-knowledge of the upper bounds of both uncertainties and external disturbances.

The remainder of this paper is organized as follows: Section 2 is dedicated to introduce type 2 fuzzy systems. In Section 3, problem statement of controlling a robotic system is treated. Section 4 is dedicated to the controller design and stability analysis. Simulation and results are given in Section 5 to show the effectiveness of the proposed approach. Finally, the conclusion is provided.

II. INTERVAL TYPE-2 FUZZY LOGIC SYSTEM

Fuzzy Logic Systems are known as the universal approximators and have several applications in control design and identification. A type-1 fuzzy system consists of four major parts: fuzzifier, rule base, inference engine, and defuzzifier. A T2FLS is very similar to a T1FLS [10] the major structure difference being that the defuzzifier block of a type-1 fuzzy system is replaced by the output processing block in a type-2 fuzzy system, which consists of type-reduction followed by defuzzification.

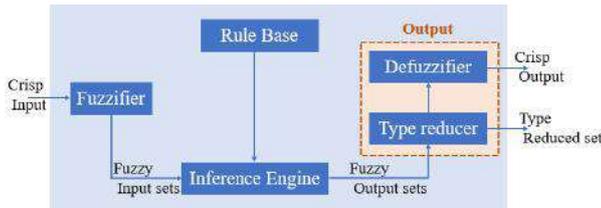


Fig. 1: Structure of a type-2 fuzzy logic system

In an interval type-2 fuzzy system, a triangular fuzzy set is defined by a lower and upper set as shown in figure 2.

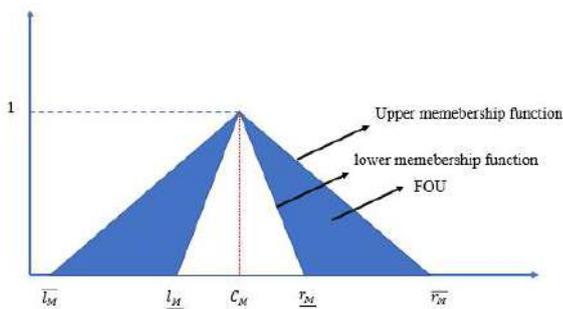


Fig. 2: Interval type-2 triangular fuzzy sets

It is clear that the interval type-2 fuzzy set is in a region bounded by an upper membership function and a lower membership function denoted as $\bar{\mu}_A(x)$ and $\underline{\mu}_A$ respectively and is named a foot of uncertainty (FOU). Assume that there are M rules in a type-2 fuzzy rule base, each of them has the following form:

R^i : IF x_1 is \tilde{F}_1^i and ... and x_n is \tilde{F}_n^i THEN y is $[w_l^i, w_r^i]$

Where $x_j, j = 1, 2, \dots, n$ and y are the input and output variables of variables of the type 2 fuzzy system, respectively, the \tilde{F}_j^i is the type 2 fuzzy sets of antecedent part, and $[w_l^i, w_r^i]$ is the weighting interval set in the consequent part. The operation of type-reduction is to give a type-1 set from a type-2 set. In the meantime, the firing strength F_i for the i^{th} rule can be an interval type-2 set expressed as:

$$F^i \equiv [\underline{f}^i, \bar{f}^i]$$

Where:

$$\begin{cases} \underline{f}^i = \underline{\mu}_{\tilde{F}_1^i}(x_1) * \dots * \underline{\mu}_{\tilde{F}_n^i}(x_n) \\ \bar{f}^i = \bar{\mu}_{\tilde{F}_1^i}(x_1) * \dots * \bar{\mu}_{\tilde{F}_n^i}(x_n) \end{cases}$$

In this work, the center of set type-reduction method is used to simplify the notation. Therefore, the output can be expressed as:

$$y_{cos}(x) = [y_l; y_r]$$

Where $y_{cos}(x)$ is also an interval type 1 set determined by left and right most points (y_l and y_r), which can be derived from consequent centroid set $[w_l^i, w_r^i]$ (either \underline{w}^i or \bar{w}^i) and the firing strength $f^i \in F^i \equiv [\underline{f}^i, \bar{f}^i]$. The interval set $[w_l^i, w_r^i]$ ($i = 1, \dots, M$) should be computed or set first before the computation of $y_{cos}(x)$. Hence, left most point y_l and right most point y_r can be expressed as:

$$\begin{cases} y_l = \frac{\sum_{i=1}^M \underline{f}^i w_l^i}{\sum_{i=1}^M \underline{f}^i} \\ y_r = \frac{\sum_{i=1}^M \bar{f}^i w_r^i}{\sum_{i=1}^M \bar{f}^i} \end{cases} \quad (1)$$

Using the center of set type reduction method to compute y_l and y_r the defuzzified crisp output from an interval type 2 fuzzy logic system can be obtained according to the following equation:

$$y(x) = \frac{y_l + y_r}{2} \quad (2)$$

Which can be rewritten on the following vectorial form:

$$y(x) = \Psi^T(x) \cdot w \quad (3)$$

Where $\Psi^T(x)$ represents the regressive vector and w the consequent vector containing the conclusion values of the fuzzy rules.

III. PROBLEM STATEMENT

Let us consider the dynamic equation of n degree-of-freedom robotic manipulators as follows

$$M(q)\ddot{q} + C(q, \dot{q})\dot{q} + G(q, \dot{q}) = \Gamma(t) + \Gamma_{ext}(t) \quad (4)$$

where q, \dot{q} and $\ddot{q} \in \mathbb{R}^n$ are the vector of joint position, joint velocity, and joint acceleration, respectively. $M(q) \in \mathbb{R}^{n \times n}$ is a symmetric and positive definite inertia matrix, $C(q, \dot{q}) \in \mathbb{R}^{n \times n}$ is the matrix of centrifugal and Coriolis forces, $G(q) \in \mathbb{R}^n$ is the vector of gravitational forces, $\Gamma(t) \in \mathbb{R}^n$ is the vector of input joint torque and $\Gamma_{ext}(t) \in \mathbb{R}^n$ is the vector of unknown external disturbances.

For practical applications, it is impossible to know the exact dynamic model of the robotic manipulators. Hence, the above dynamic quantities can be expressed as:

$$\begin{aligned} M(q) &= M_0(q) + \Delta M(q) \\ C(q, \dot{q}) &= C_0(q, \dot{q}) + \Delta C(q, \dot{q}) \\ G(q) &= G_0(q) + \Delta G(q) \end{aligned} \quad (5)$$

Where $M_0(q)$, $C_0(q, \dot{q})$, $G_0(q)$ are the nominal values of $M(q)$, $C(q, \dot{q})$, $G(q)$ respectively and $\Delta M(q)$, $\Delta C(q, \dot{q})$, $\Delta G(q)$ are the uncertain parts of $M(q)$, $C(q, \dot{q})$, $G(q)$ respectively.

Using equation (5), the dynamic model of the robotic manipulators can be expressed as:

$$M_0(q)\ddot{q} + C_0(q, \dot{q})\dot{q} + G_0(q, \dot{q}) = \Gamma(t) + \delta(q, \dot{q}, \ddot{q}) \quad (6)$$

Where:

$$\delta(q, \dot{q}, \ddot{q}) = \Gamma_{\text{ext}}(t) - \Delta M(q)\ddot{q} - \Delta C(q, \dot{q})\dot{q} - \Delta G(q)$$

Let define the tracking error $e = q - q_d$ and its time derivative $\dot{e} = \dot{q} - \dot{q}_d$ where q_d the desired trajectory. Then the error dynamic of the robotic manipulators with the uncertainties and disturbances can be written as:

$$\ddot{e} = f(e, \dot{e}) + g(e, \dot{e})\Gamma(t) + D(e, \dot{e}) \quad (7)$$

Where $f(e, \dot{e}) = -M_0^{-1}(q)[C_0(q, \dot{q})\dot{q} + G_0(q, \dot{q})] - \ddot{q}_d$, $g(e, \dot{e}) = M_0^{-1}(q)$ and $D(e, \dot{e}) = M_0^{-1}(q)\delta(q, \dot{q}, \ddot{q})$.

As given in [14], the upper bound of lumped uncertainty can be expressed as:

$$|D(e, \dot{e})| \leq a_0 + a_1|q| + a_2|\dot{q}|^2 \quad (8)$$

Where b_0 , b_1 and b_2 are positive scalars.

The next task is to develop a robust controller based on nonsingular fast terminal sliding mode control allowing to tracking objectives.

IV. CONTROLLER DESIGN

To design our controller, let consider the following nonsingular terminal sliding surface:

$$S(t) = e + k_1|e|^\alpha \text{sign}(e) + k_2|\dot{e}|^\beta \text{sign}(\dot{e}) \quad (9)$$

Where k_1 and k_2 are positive constants, $1 < \beta < 2$ and $\alpha > \beta$.

The structure of this surface allows us to attain fast convergence of the tracking error to zero. Indeed, if the position initial value is far from the desired one, then the term $k_1|e|^\alpha \text{sign}(e)$ will be dominant, which leads to a fast convergence. In the case where the system is near the desired trajectory, the term $k_2|\dot{e}|^\beta \text{sign}(\dot{e})$ must ensuring a finite time convergence.

The time derivative of the sliding surface can be written as:

$$\dot{S}(t) = \dot{e} + \alpha.k_1|e|^{\alpha-1}\dot{e} + \beta.k_2|\dot{e}|^{\beta-1}.\ddot{e} \quad (10)$$

Our control law will be composed from two terms. The first one, named equivalent control $\Gamma_e(t)$, is dedicated to maintain the system on the sliding surface. The second term, $\Gamma_s(t)$ called switching signal, must force the system to converge to the sliding surface. Then, to design the equivalent control law $\Gamma_e(t)$, we consider that the system is on the surface ($S(t) = 0$) and remains on ($\dot{S}(t) = 0$). In this case, the system is considered insensitive to uncertainties and external disturbances (Slotine, 1991).

Using (7) equation (10) can be rewritten as:

$$\dot{S}(t) = \dot{e} + \alpha.k_1|e|^{\alpha-1}\dot{e} + \beta.k_2|\dot{e}|^{\beta-1}.[f(e, \dot{e}) + g(e, \dot{e})\Gamma_e(t)] \quad (11)$$

Then the expression of equivalent control law can be expressed as:

$$\Gamma_e(t) = -g^{-1}(e, \dot{e}).[f(e, \dot{e}) + [\beta.k_2]^{-1}|\dot{e}|^{2-\beta}(1 + \alpha.k_1|e|^{\alpha-1}) \text{sign}(\dot{e})] \quad (12)$$

Note that, we used the fact that $\dot{e} = |\dot{e}|.\text{sign}(\dot{e})$ to write equation (9) in a compact form.

Our next task is to determine the expression of the switching signal $\Gamma_s(t)$ allowing to force the system to reach the sliding surface in presence of uncertainties and external disturbances.

In this case, equation (10) becomes:

$$\dot{S}(t) = \dot{e} + \alpha.k_1|e|^{\alpha-1}\dot{e} + \beta.k_2|\dot{e}|^{\beta-1}.[f(e, \dot{e}) + g(e, \dot{e})\Gamma(t) + D(e, \dot{e})] \quad (13)$$

Using (12), we can rewrite (10) as:

$$\dot{S}(t) = \dot{e} + \alpha.k_1|e|^{\alpha-1}\dot{e} + \beta.k_2|\dot{e}|^{\beta-1}.[f(e, \dot{e}) + g(e, \dot{e})\Gamma_e(t)] + \beta.k_2|\dot{e}|^{\beta-1}.[g(e, \dot{e})\Gamma_s(t) + D(e, \dot{e})] \quad (14)$$

According to the definition of the equivalent control, equation (14) can be simplified to:

$$\dot{S}(t) = \beta.k_2|\dot{e}|^{\beta-1}.[g(e, \dot{e})\Gamma_s(t) + D(e, \dot{e})] \quad (15)$$

To deduce the expression of $\Gamma_s(t)$ allowing the switching condition, we consider the following Lyapunov function:

$$V(t) = \frac{1}{2}S^2(t) \quad (16)$$

Differentiating $V(t)$ with respect to time and using (15) lead to:

$$\dot{V}(t) = S(t).\beta.k_2|\dot{e}|^{\beta-1}.[g(e, \dot{e})\Gamma_s(t) + D(e, \dot{e})] \quad (17)$$

Choosing $\Gamma_s(t)$ as:

$$\Gamma_s(t) = -g^{-1}(e, \dot{e})[k_{01}.S(t) + (k_{02} + a_0 + a_1|q| + a_2|\dot{q}|^2).sign(S(t))] \tag{18}$$

Where k_{01} and k_{02} are two positive scalars.

The time derivative of the Lyapunov function becomes:

$$\begin{aligned} \dot{V}(t) &= S(t). \beta. k_2 |\dot{e}|^{\beta-1}. [g(e, \dot{e})\Gamma_s(t) + D(e, \dot{e})] \\ &= \beta. k_2 |\dot{e}|^{\beta-1}. \left[- \begin{matrix} -k_{01}.S^2(t) \\ (k_{02} + a_0 + a_1|q| + a_2|\dot{q}|^2).|S(t)| \\ +D(e, \dot{e}) \end{matrix} \right] \end{aligned} \tag{19}$$

Using the assumption (8), we obtain the following inequality:

$$\dot{V}(t) \leq \beta. k_2 |\dot{e}|^{\beta-1}. [-k_{01}.S^2(t) - k_{02}.|S(t)|] \leq 0 \tag{20}$$

Based on the Lyapunov theorem, the system converges asymptotically to the sliding surface and remains on.

To prove convergence in finite time, let us take up inequality (20):

$$\dot{V}(t) \leq -\beta. k_{01}. k_2 |\dot{e}|^{\beta-1}. S^2(t) - \beta. k_{02}. k_2 |\dot{e}|^{\beta-1}. |S(t)| \tag{21}$$

$$\begin{aligned} \dot{V}(t) &= \frac{dV(t)}{dt} \leq -2. \beta. k_{01}. k_2 \underbrace{|\dot{e}|^{\beta-1}}_{\beta_1}. V(t) - \\ &\underbrace{\sqrt{2}\beta. k_{02}. k_2 |\dot{e}|^{\beta-1}}_{\beta_2}. V^{\frac{1}{2}}(t) \end{aligned} \tag{22}$$

Then we can obtain:

$$dt \leq \frac{-dV(t)}{\beta_1.V(t) + \beta_2.V^{\frac{1}{2}}(t)} = -2. \frac{dV^{\frac{1}{2}}(t)}{\beta_1.V^{\frac{1}{2}}(t) + \beta_2} \tag{23}$$

If we consider that the system converges to 0 at $t = t_r$ implies that:

$$\int_0^{t_r} dt \leq \int_{V(0)}^{V(t_r)} \frac{-2.dV^{\frac{1}{2}}(t)}{\beta_1.V^{\frac{1}{2}}(t) + \beta_2} = \left[-\frac{2}{\beta_1} \ln(\beta_1 V^{\frac{1}{2}}(t) + \beta_2) \right]_{V(0)}^{V(t_r)} \tag{24}$$

Hence,

$$t_r \leq \frac{2}{\beta_1} \ln \left(\frac{\beta_1 V^{\frac{1}{2}}(0) + \beta_2}{\beta_2} \right) \tag{25}$$

Consequently, the control law $\Gamma(t) = \Gamma_e(t) + \Gamma_s(t)$, whose terms are defined by equations (12) and (18), guarantees the asymptotic stability of the closed loop system and the convergence of the tracking error in a finite time.

Nevertheless, it is very difficult if not possible to know the exact values of the scalars a_0 , a_1 and a_2 . To overcome this problem, we propose to approximate them by three adaptive type 2 fuzzy systems $\hat{a}_0 = \Psi^T(e, \dot{e}).w_0$, $\hat{a}_1 = \Psi^T(e, \dot{e}).w_1$ and $\hat{a}_2 = \Psi^T(e, \dot{e}).w_2$. According to the universal approximation theorem, there exists an optimal values of type 2 fuzzy systems we can write:

$$\begin{aligned} a_0 &= \Psi^T(e, \dot{e}).w_0^* \\ a_1 &= \Psi^T(e, \dot{e}).w_1^* \\ a_2 &= \Psi^T(e, \dot{e}).w_2^* \end{aligned} \tag{26}$$

Where w_0^* , w_1^* and w_2^* represent the optimal values of w_0 , w_1 and w_2 respectively.

Consequently, the control laws become:

$$\begin{aligned} \Gamma(t) &= \Gamma_e(t) + \Gamma_s(t) \\ \Gamma_e(t) &= -g^{-1}(e, \dot{e}). [f(e, \dot{e}) + [\beta. k_2]^{-1} |\dot{e}|^{2-\beta} (1 + \alpha. k_1 |e|^{\alpha-1}) sign(\dot{e})] \\ \Gamma_s(t) &= -g^{-1}(e, \dot{e})[k_{01}.S(t) + (k_{02} + \hat{a}_0 + \hat{a}_1|q| + \hat{a}_2|\dot{q}|^2).sign(S(t))] \end{aligned} \tag{27}$$

These modified control laws allow to ensure the convergence to the reference trajectory in a finite time.

To deduce the adaptation laws of the three adaptive fuzzy system, we consider the new Lyapunov function:

$$V(t) = \frac{1}{2}S^2(t) + \beta. k_2 \left(\frac{1}{2\gamma_0} (w_0 - w_0^*)^2 + \frac{1}{2\gamma_1} (w_1 - w_1^*)^2 + \frac{1}{2\gamma_2} (w_2 - w_2^*)^2 \right) \tag{28}$$

Using the control laws (27) and the following adaptation laws:

$$\begin{aligned} \dot{w}_0 &= \gamma_0 \Psi^T(e, \dot{e}). |S(t)|. |\dot{e}|^{\beta-1} \\ \dot{w}_1 &= \gamma_1 \Psi^T(e, \dot{e}). |S(t)|. |\dot{e}|^{\beta-1} |e| \\ \dot{w}_2 &= \gamma_2 \Psi^T(e, \dot{e}). |S(t)|. |\dot{e}|^{\beta} \end{aligned} \tag{29}$$

And following the same mathematical development used previously, the time derivative of the Lyapunov function (28) becomes:

$$\dot{V}(t) \leq \beta. k_2 |\dot{e}|^{\beta-1}. [-k_{01}.S^2(t) - k_{02}.|S(t)|] \leq 0 \tag{30}$$

Thus, the convergence of the closed loop system to the reference trajectory in a finite time is guaranteed.

V. SIMULATION AND RESULTS

To show the performances of the performances of the proposed approach, we consider a one link robot, shown in fig. 3, whose dynamics equation is given by:

$$m_1^2 \ddot{q} + m_1 g l \cos(q) \dot{q} + m_1 g l \sin(q) = \Gamma + \Gamma_{ext}(t)$$

With: $m_1 = 1Kg$; $l_1 = 1m$; $g = 9.8ms^{-2}$

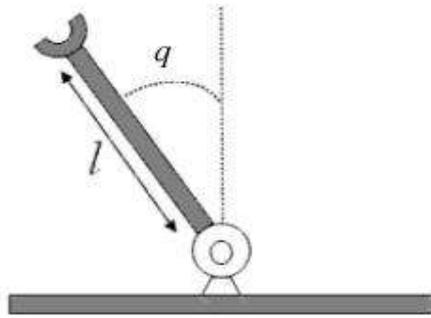


Fig. 3: One link robot manipulator

To construct the type 2 fuzzy nominal model, we consider that the position q is constrained within $[-\frac{\pi}{2}; \frac{\pi}{2}]$, which leads to 3 fuzzy rules. Each one of them gives the relation between the equilibrium point and the corresponding local model. Then, each rule uses a type 2 fuzzy sets in the antecedent part to describe the equilibrium point and the consequent part the corresponding local model. Using the product as an interference engine, the method of center set for the reduction type and center of gravity for defuzzification, the output fuzzy system will be giving the type 2 fuzzy nominal model.

Fig. 4 gives the angular position and velocity for two initial positions. The convergence to zero in a finite time is well shown in fig. 5. To illustrate the efficiency of the proposed approach we have used a more complex trajectory,

$q_q = 0.5\cos(t) + 0.5\sin(2t)$. Fig. 6 gives the angular position and velocity for two initial values. These results show also the good tracking performances and the convergence to the reference trajectory in a finite time. Furthermore, the control signal given by fig. 7 the elimination of the chattering phenomenon and the smooth control signal. We can conclude that the proposed approach ensures high tracking precision, fast response, singularity avoidance and strong robustness to external disturbances and modeling uncertainties.

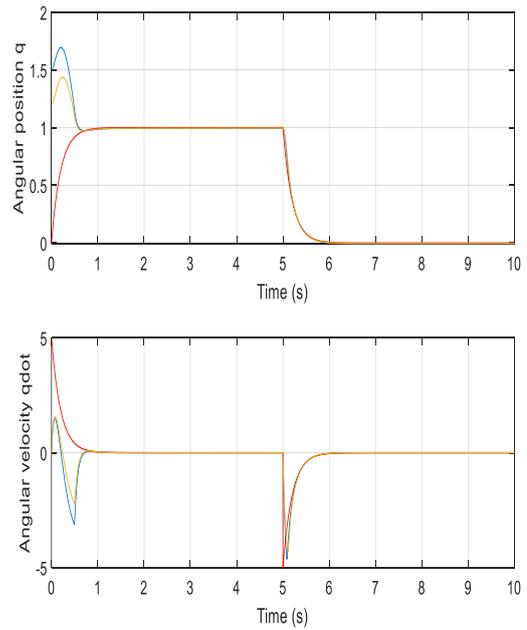


Fig. 4: Angular position and velocity tracking

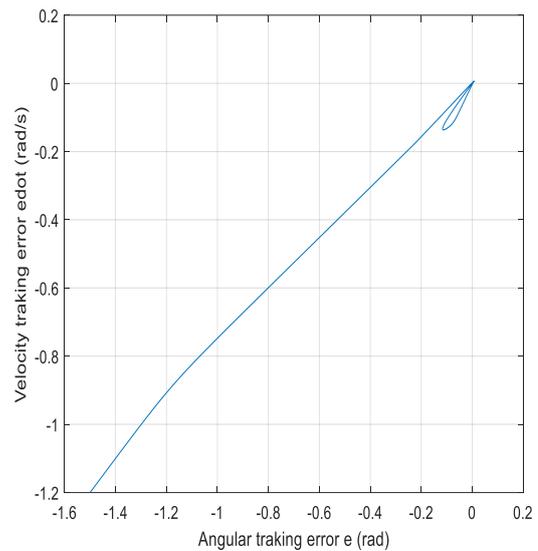


Fig. 5: Error phase plane

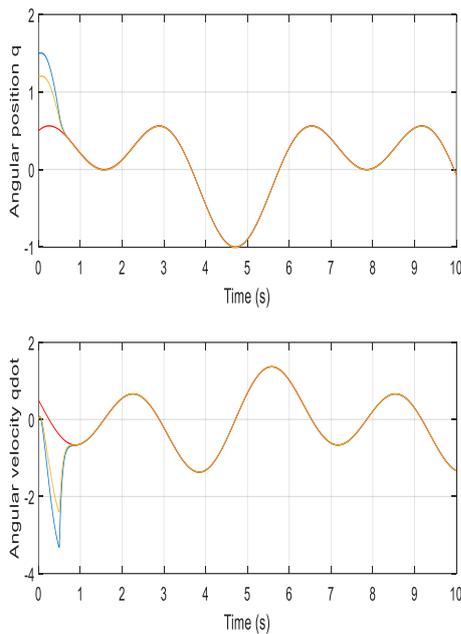


Fig. 6: Angular position et velocity tracking

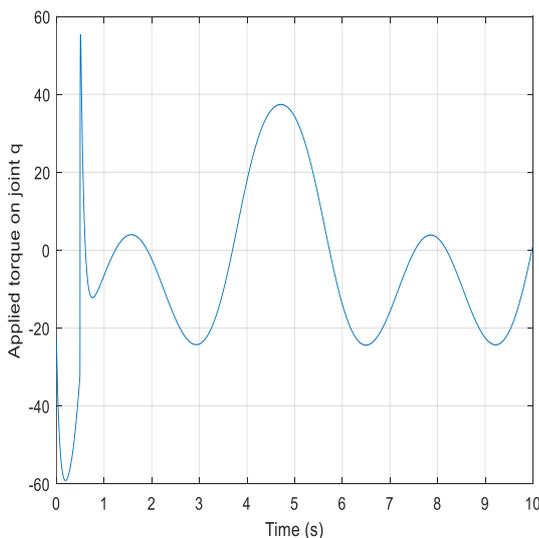


Fig. 7: Applied control signal

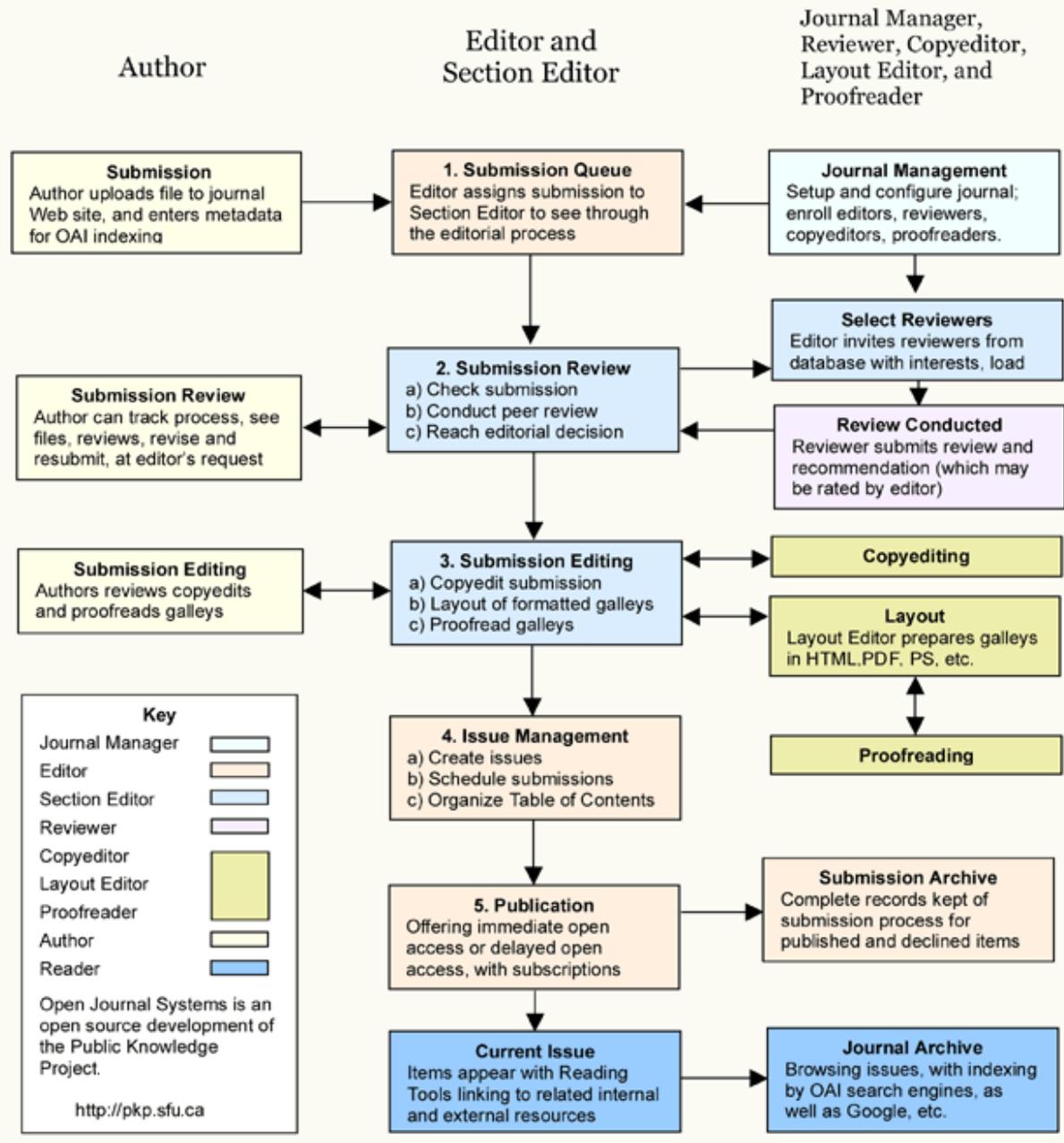
VI. CONCLUSION

In this paper, a combination of type 2 fuzzy logic and nonsingular fast sliding mode control for robotic systems is presented. The proposed approach allows to overcome the drawbacks encountered in classical cases, thanks to type 2 fuzzy logic. Several simulation results have presented to show the efficiency of the proposed approach despite the presence of modeling uncertainties and external disturbances. As perspective of this work to improve the control law design by reducing number of used parameters.

REFERENCES

- [1] J.-J. E. Slotine, W. Li, and others, Applied nonlinear control, vol. 199. Prentice hall Englewood Cliffs, NJ, 1991.
- [2] Y. Pan, C. Yang, L. Pan and H. Yu, "Integral Sliding Mode Control: Performance, Modification, and Improvement," in IEEE Transactions on Industrial Informatics, vol. 14, no. 7, pp. 3087-3096, July 2018.
- [3] A. Hamzaoui, N. Essounbouli, and J. Zaytoon, "Fuzzy sliding mode control with a fuzzy switching function for non-linear uncertain multi-input multi-output systems," Proc. Inst. Mech. Eng. Part J. Syst. Control Eng., vol. 218, no. 4, pp. 287–297, 2004.
- [4] M. Manceur, L. Menhour, N. Essounbouli, and A. Hamzaoui, "MIMO sliding fuzzy type-2 control with manipulating approaching phase," in 2013 10th IEEE International Conference on Networking, Sensing And Control (ICNSC), IEEE, 2013, pp. 479–485.
- [5] P. Vivekanandan et al., "Modelling, Simulation and Control of 5 Axis Industrial Robot using MATLAB," Indian J. Sci. Technol., vol. 12, no. 23, pp. 1–7, Jun. 2019.
- [6] H. Wang et al., "Design and implementation of adaptive terminal sliding-mode control on a steer-by-wire equipped road vehicle," IEEE Trans. Ind. Electron., vol. 63, no. 9, pp. 5774–5785, 2016.
- [7] Y. Feng, X. Yu and Z. Man, "Non-singular terminal sliding mode control and its application for robot manipulators," ISCAS 2001. The 2001 IEEE International Symposium on Circuits and Systems (Cat. No.01CH37196), Sydney, NSW, Australia, 2001
- [8] Alattas, K.A.; Mostafae, J.; Alanazi, A.K.; Mobayen, S.; Vu, M.T.; Zhilenkov, A.; Abo-Dief, H.M. Nonsingular Terminal Sliding Mode Control Based on Adaptive Barrier Function for n^{th} -Order Perturbed Nonlinear Systems. *Mathematics* **2022**,
- [9] Wang, L. and Yang, J., Nonsingular fast terminal sliding-mode control for nonlinear dynamical systems. Int. J. Robust Nonlinear Control, 21: 1865-1879, 2011.
- [10] N. N. Karnik, J. M. Mendel, and Q. Liang, "Type-2 fuzzy logic systems," IEEE Trans. Fuzzy Syst., vol. 7, no. 6, pp. 643–658, 1999.

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