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The Difficulties Faced by the Transexual Citizen During the Sexual Redesignation Process: A review of literature

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***Palavras*– chaves: medicina, redesignação sexual, transexual.**

Abstract— Introduction: The process of sexual reassignment has been a topic of political, medical, social and anthropological debate. Sex reassignment is characterized as the process that individuals who do not identify with the gender they were assigned at birth go through in order to correct what they believe is appropriate. Objective: To identify the difficulties faced by transsexual citizens during the process of sexual reassignment. Method: The work carried out followed the precepts of an exploratory study, through bibliographic research following the stages: 1st selection of the most relevant databases and articles on the process of sexual reassignment, from the last 5 years (2016-2021) which resulted in 36 national articles, 4 international articles and 2 books taken from the Google Scholar, Scielo, PUBMED, LILACS, MEDLINE databases, in Portuguese, English, Spanish and French. 2nd data collection with selective and exploratory reading, followed by recording the information collected. 3rd analysis and interpretation of the results after analytical reading of the data collected. 4th discussion of the results, after in-depth analysis of the theoretical references relating to the subject of the study. Results: In relation to this phenomenon, it is understood that the purpose of the correction, in the case of transsexuals, is the marked disharmony between sex and gender, which sometimes causes unbearable suffering, arising from the coercive force of gender on sex, suffering that impels them to demand that medicine intervene in the real body. Faced with this reality, various outpatient-surgical methods have been offered to these individuals, but it is clear that there are many obstacles to achieving this process.

***Resumo**— Introdução: O processo de redesignação sexual tem sido tema nos debates políticos, médicos, sociais e antropológicos. Caracteriza-se a redesignação sexual como o processo que indivíduos, ao não se identificarem com o gênero designado no nascimento, querem passar para corrigir o que acreditam ser cabível. OBJETIVO: Identificar as*

dificuldades enfrentadas pelo cidadão transexual durante o processo de redesignação sexual. MÉTODO: O trabalho desenvolvido seguiu os preceitos do estudo exploratório, por meio de pesquisa bibliográfica seguindo as etapas: 1ª seleção das bases dados e dos artigos de maior relevância sobre o processo de redesignação sexual, dos últimos 5 anos (2016-2021) os quais resultaram em 36 artigos nacionais, 4 internacionais e 2 livros retirados das bases google acadêmico, Scielo, PUBMED, LILACS, MEDLINE, nos idiomas português, inglês, espanhol e francês. 2ª coleta de dados com a leitura seletiva e exploratória, seguido do registro das informações colhidas. 3ª analise e interpretação dos resultados após a leitura analítica dos dados colhidos. 4ª discussão dos resultados, após análise profunda dos referencias teóricos relativo a temática do estudo. RESULTADOS: Relacionado à esse fenômeno compreende-se que o intuito da correção, no caso do transexual, seja a acentuada desarmonia entre sexo e gênero, que por vezes ocasiona um sofrimento insuportável, oriundo da forca coercitiva do gênero sobre o sexo, sofrimento que o/a impele a demandar a medicina a intervenção no real do corpo. Diante dessa realidade, diversos métodos ambulatórias-cirúrgicos têm sido oferecidos a esses indivíduos, no entanto, percebe-se que muitos são os obstáculos para o alcance final desse processo.

I. INTRODUCTION

The topic of gender reassignment/identity is still considered new. Gender identity (the gender a person identifies as) has been the central theme in the most diverse political, medical, social and anthropological debates. In order to discuss gender identity/ reassignment and the process of transsexualization, it is necessary to understand the concept of gender. The Aurélio mini-dictionary (2019, p. 430) found the following: "[...] the way in which the sexual identity of individuals manifests itself, socially and culturally [...] [...] **Human gender**. The human species; humanity [...]".

Frota (2004, p.16), analyzing gender, points out

> According to this definition, gender is a social category imposed on the sexed body. With the proliferation of these studies, gender has become a particularly useful word, as it offers a means of distinguishing sexual practice from the sexual roles assigned to women and men.

Sousa (2012, p 50) explains: "It is understood that humanity is diverse and this diversity manifests itself in the perception that one has of the other and of oneself [...]". The genesis of the topic of gender reassignment/identity is the condition of some individuals whose gender identity differs from that assigned at birth, who even without surgery to change their physical structure, are defined as transsexuals, and the center of these discussions lies in the discrimination and exclusion that has occurred throughout history. In the field of health, this is no different, especially with regard to care and access to health services (WINTER, et al. 2016).

Jorge and Travassos (2018, p.11), when analyzing transsexuality, point out that "In Brazil, the subject has invaded the media, cultural and entertainment magazines...[...] Suddenly, transsexuality is spoken of colloquially, without any surprise or inquiry". Even with all the visibility, surveys indicate that discrimination is a present situation for transsexuals and also occurs in the health area, these surveys indicate that 19% of respondents cited having already been refused medical care because they are transsexuals.

Transsexuality has a rather peculiar characteristic that leads it to be considered a social phenomenon: it is marked by self-diagnosis and therapeutic self-prescription, i.e. the

(Jorge and Travassos, 2018, p.57). The subject self-identifies in a certain description - which they have seen in the media or seen someone say - and goes to the doctor asking for the "correction" that they have been told is appropriate. It is understandable that the purpose of this correction, in the case of transsexuals, is the marked disharmony between sex and gender, which sometimes causes unbearable suffering, stemming from the coercive

force of gender over sex, suffering that impels them to demand that medicine intervene in the real body. (JORGE and TRAVASSOS, 2018, p.47)

The process of vulnerability in health can increase the chances of the user being exposed to illness through individual, collective and contextual factors that cause, to a greater or lesser degree, a risk of physical and psychological illness. The individual factor refers to the degree of information that people have about themselves and what is necessary and safe for the transsexualizing process. The collective factor covers access to health services and their adaptations to include users. The current social factor is maintaining the participation of these individuals in society, and they should be allowed to submit to the rights and duties of any other citizen above the law. (BORBA, et al. 2016).

Based on the assumptions organized by the concept of vulnerability, in this study, the participants in the research process are represented by the group of gender and sexuality minorities, brought up in this context as part represented in the acronym LGBTQIAP+ (Lesbian, Gay, Bi, Trans, Queer/Questioning, Intersex, Asexual/Aromantic/Gender, Pan/Poli, and more). Based on this perspective of weaknesses in health care for this population, the importance of a specific policy for health care was signaled. Thus, in 2011, the National Comprehensive Health Policy for the LGBTQIAP+ Population emerged as a response to historically stigmatized demands and specificities, with the aim of promoting equity and implementing a state policy to guarantee human rights. (RIBEIRO, et al. 2016)

Specifically with regard to access, it is worth highlighting this as an essential part of health care for Brazilian transsexuals. Access is pointed out as a *sine qua non* (indispensable) condition in the structuring of any health service, from formal or informal entry into health facilities, through the use of services, to the end of care practices. Access should not be limited to the entrance. For this reason, they use the concept of accessibility in its broadest format, which includes the different potentialities of health territories, in order to foster adaptations with a view to including users. (MONTEIRO, et al. 2019)

However, the transgender population's access to the SUS is difficult to operationalize, since this population does not follow a heteronormative pattern, and what makes them "different" can end up being used against them in the health services. An example of this is the non-use of the social name to identify the patient, which often leads a trans person to embarrassment, such as a girl standing up to the doctor in a doctor's office by a male name, for example. In this way, the state ends up incorporating the trans population, through the logic of the services offered, as a community of perverts, undesirables. Therefore, they may have their right to access health care violated, giving rise to a "non-place" in the SUS and reproducing weaknesses in the effectiveness of care. (ROCON, et al. 2016)

Social institutions, such as religion or family, which are stratified in society, also influence gender identity and, consequently, the ways in which health care is provided by professionals from the different areas of knowledge in the health sciences. Thus, transsexual users can suffer discrimination and stigmatization, represented by difficulties in accessing health services, which can influence the search for clandestine services, which, due to their general precariousness, can offer risk and, above all, raise vulnerability standards, facts that demonstrate the importance of increasing the use of soft technologies in LGBTQIAP+ health, without disregarding the others (PARDINI, et al. 2017).

Objective

Identify the difficulties faced by transsexual citizens during the sex reassignment process.

II. CONTEXT THEORETICAL

2.1 Transsexuality

Transsexuality is a complex and universal phenomenon, occurring in many different times and places in the history of civilization. Today, it is defined as the persistent desire to live and be accepted as a person of the opposite sex. These individuals may experience psychological discomfort because of their biological sex and wish to undergo surgery or hormone treatments to redefine their bodies (DAVIS, et al., 2012, apud, SILVA, et al., 2017).

In Brazil, the Federal Council of Medicine (CFM) published Federal Resolutions No. 1,$^{482/199716}$, No. 1,$^{652/200217}$ and No. 1,$^{955/201018}$, diagnosing transsexual patients as having a permanent psychological disorder, with rejection of the phenotype and a tendency towards self-extermination or self-mutilation. In this way, it allows transgenitalization surgeries to be performed as a way of therapeutically correcting cases of transsexuality (CONSELHO FEDERAL DE PSICOLOGIA, CFP, 2011 apud, SILVA, et al., 2017).

2.2 Depathologization of Transsexuality

With regard to transsexuals, it is known that this is a complete and universal phenomenon, occurring in various cultures at different times and places in human

history. The process of depathologizing these identities can be considered a topical issue for both science and society. In 2010, France was the first country in the Western world to declassify transsexuality as a psychological disorder, while in India, Pakistan and Bangladesh, the hijras (a Hindu religious community made up of transsexuals) were legitimized and made official with the nomenclature of the Third Sex.

In Brazil, the CFP (Federal Psychology Council), considering the right to citizenship, as well as equality and the dignity of the human person, guaranteed by the Federal Constitution, enacted Resolution No. 014 of 2011, allowing transvestite and transsexual psychologists to use their social names in the "observation" field of their identification cards professional. This publication sets precedents for questioning and consequently changing the way Brazilian psychology understands the experience of transsexuals.

In 2013, the publication of the technical note on the transsexualization process and other forms of assistance for trans people became a milestone in the process of depathologization. As an official guidance document for psychologists working to promote the mental health of this population, the CFP states that transsexuality and transvestitism are not psychopathologies, although they are expressions of gender and non-normative sexuality. In 2014, the communication campaign for the depathologization of these identities was officially regularized (silva, et al., 2017).

2.3 Transsexuality and the risk of becoming ill

The expressions of transsexual groups, when analyzed based on the concept of vulnerability in health - which leads to a more reflective view of collective health, in which there are predictors of susceptibility to illness - include everything from epidemiological issues to modifications to provide inclusion in health services. Nevertheless, conservatism is intrinsically linked to the marginalization of this social group, which makes it impossible for transsexuals to enter the job market, leading to their oppression in the illegal world of prostitution, thus favoring health risks. These victims use clandestine prostheses to bargain for space in the prostitution market and ingest artificial hormones for the transsexualizing process (SCHELLER, et al. 2017).

III. METHODOLOGY

3.1 Type of Study

This research qualifies as an integrative literature review and followed the precepts of an exploratory study, since it is a study carried out through bibliographic surveys which, according to Gil (2021), "is developed from material already prepared, consisting of books and scientific articles".

3.2 Inclusion and Exclusion Criteria

For the inclusion criteria, articles and books that addressed the subject and dealt with the topic were accepted, and for the exclusion criteria, articles and books that did not address the subject and did not deal with the topic were rejected.

3.3 Materials and Methods

Data was collected using scientific articles found in the following databases: Google Scholar, Scielo, PUBMED, LILACS and MEDLINE.

From the perspective of Gil's (2021) proposal, this study was carried out in 4 (four)

steps:

Stage 1 - Sources

The sources that provided the appropriate answers to the proposed problem are described below:

3.3.1 Two books were used that addressed the topic, in terms of the health aspects of the transsexual population and the technique for medical care for them, in Portuguese, available on the internet, published in 2016 and 2018.

3.3.2 Selection of the most relevant published articles on the sex reassignment process using the Google Scholar, Scielo, PUBMED and LILACS databases, MEDLINE, published in the last 5 years (2016 to 2021). We used 36 national and 4 international articles, available online in full text. The following descriptors were used: transsexualizing process, transsexual health, care for transsexuals, transphobia in the health system.

Stage 2 - Data Collection

Data collection was based on the following premise:

a) Exploratory reading of all the material selected (quick reading to see if the work consulted is of interest to the work);

b) Selective Reading (more in-depth reading of the articles included and the parts that really interest you);

c) Recording the information extracted from the sources in a specific instrument (authors, year, method, results and conclusions).

Stage 3 - Analysis and Interpretation of Results

In this stage, an analytical reading was carried out in order to order and summarize the information contained in the sources, so that they could provide answers to the research problem.

Stage 4 - Discussion of Results

Categories that emerged from the previous stage were analyzed and discussed based on the theoretical framework related to the subject of the study.

IV. ETHICAL ASPECTS

There was a commitment to cite the authors used in the study in accordance with Brazilian regulatory standard 6023, which sets out the elements to be included and guides the compilation and production of references. The data collected was used exclusively for scientific purposes.

V. RESULTS

To carry out this bibliographical review, data was collected from a total of 229 scientific articles, of which 187 did not meet the exclusion criteria and did not contain pertinent information on the process of sexual reassignment, leaving 42 works that met the inclusion criteria, from which the following were taken: 3 from MedLine, 9 from Google Scholar, 4 from LILACS, 18 from Scielo, 7 from PUBMED, and 2 from Med Sus.

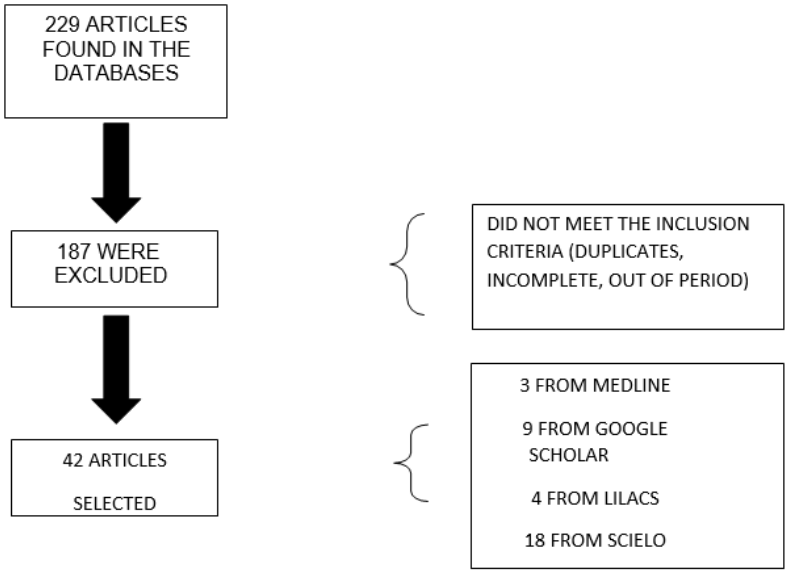

Fig.1 - Flowchart of article selection

Source: survey data

Table 1 - The difficulties faced by transsexual citizens during the sex reassignment process: literature review

NO.	AUTHOR/YEAR	METHODOLOGY	RESULTS
1	Sam Winter, et al, 2016	in this article, we examine the social conditions and in which many transgender people (often people calls trans) live and medical perspectives that frame the provision of health care for transgender people in much of the world.	Some governments are taking measures to address issues of human rights and provide better legal protection for transgender people, but this action is not by no means universal.
2	Jéssica Leite Serrano, et al, 2019	Eight trans men who use the services offered by the Comprehensive Health Outpatient Clinic for Transvestites and Transsexuals in the city of João Pessoa/PB took part in the study. They were subjected to a semi-structured interview and a socio-	This study concluded that the interviewees use physical activities to gain body mass and muscle definition, aspects that in their view refer to a masculine body, reinforcing not only their masculinity, but also helping to build their sexual identity.

		economic questionnaire, which were analyzed based on Bicudo's proposal for phenomenological analysis.	
3	Pamela Suelen de Oliveira Reis, et al, 2021	Socio-anthropological studies were used to analyze and discuss the data, and field research was used as a methodological reference.	The meanings produced by nurses about welcoming transvestites and transsexuals in primary care are based on issues such as embarrassment, neutrality and lack of knowledge about gender issues beyond gender binarism.
4	Pablo Cardozo Rocon, et al, 2016	A qualitative approach was used through semi-structured interviews with 15 trans people.	The results pointed to disrespect for the social name, discrimination and diagnosis in the transsexualizing process as the main limitations in accessing the health system.
5	Gianna Schreiber Popadiuk, et al, 2017	The exploratory research combined quantitative and qualitative methods of study, taking as methodological basis for the normative research proposal for the evaluation of health programs and systems.	The study resulted in a total of sexual reassignment carried out in the SUS (2008-2016), which show no deaths and regional inequalities in access;.
6	Fernando Scheller, 2017	Semi-structured interviews with representatives of these organizations examined their perceptions of the challenges faced by transsexuals and transvestites in accessing work.	some of which depend on state action, such as affirmative action, and others which require corporate responsibility.
7	Monique Mendes, et al, 2020	Case report	Currently, most reports come from countries in Asia and South America and the victims are mainly women and transsexuals. One case of death of a transsexual patient after injection of industrial silicone into the thighs and buttocks is reported.
8	Nizar Amin Shihadeh, et al, 2021	The method adopted as a guiding principle for analyzing reality in order to carry out the research was the dialectical-critical method, whose central categories are totality, historicity and contradiction, seeking coherent, logical and rational explanations, in order to try to understand the reality we are trying to investigate, which is not something ready and unfinished, because we need to build paths in order to analyze possibilities for finding possible transformations so as not to run the risk of present preconceived opinions.	LGBTQIAphobia may be perpetuated by the lack of training and unpreparedness of health professionals, which manifests itself in cycles of violence, such as difficulties in guaranteeing humanized, equitable and comprehensive health care, in addition to encountering difficulties that cause suffering and various constraints, which prevent particular and specific demands from being met, including, for example, guaranteeing the use of the social name of transvestites and transsexuals, the prevention of new cases of gynecological cancers (cervical and breast) among lesbians and bisexual women and also new cases of prostate cancer among gay men, bisexual men, transvestites and transsexuals, as well as expanding access to treatment for these diseases.
9	Pablo Cardozo Rocon, et al, 2019	It is understood that qualitative methodology is ideal for analyzing the "products of the interpretations that humans make about how they live, build their artifacts and themselves, feel and think".	As of September 9, 2018, ten establishments had been qualified to offer the SUS transsexualizing process. From a geographical point of view, the units qualified to offer the SUS Transsexualizing Process, both in hospital and outpatient, are

			mostly concentrated in the Southeast, with six of the ten units, followed by the South, with two units, and the Northeast and Midwest, with one unit each.
10	Cecília Barreto, et al, 2018	Semi-structured interviews with representatives of these organizations examined their perceptions of the challenges faced by transsexuals and transvestites in accessing work.	As a result, we identified five main challenges: prejudice and transphobia, as well as training for both trans people and companies.
11	Maureen K. Flynn, et al, 2021	Participants were recruited through advertisements on social media sites (e.g. Facebook), Reddit and organizations that serve minorities gender and 402 participants were included in the statistical analyses.	The results showed that both psychological flexibility and inflexibility moderated the relationship between 1) transphobia internalized and life satisfaction and 2) non-disclosure of gender identity and satisfaction with life.
12	Lucas Périco, 2021	This type of research makes a collection of information from field notes, interviews, conversations, photographs, personal notes, among others, into a comprehensive approach to a subject, which will be supported by the chosen theoretical framework.	On the one hand, a standard of masculinity and femininity linked to anatomical and physiological issues is demanded, i.e. the reproductive system determines how a person should dress, speak, express themselves, etc.
13	Estevão Rafael Fernandes, et al, 2019	Based on qualitative research, this article seeks to analyse the use of social networks as strategies for the visibility of transgender individuals, acting as the creation of political spaces in the construction of concrete events, in the interaction of political subjects, spaces of excellence for leadership policies and the commitment of groups to struggles for recognition as well as social and political mobilization.	One of these "non-writings" concerns the rise of LGBTphobia on and off the internet, as a result of the growing political polarization in the country over the last few years - notably from 2013 to the present.
14	São Paulo Municipal Health Department, 2020	The Technical Committee for Comprehensive Health for the LGBTI Population (Lesbian, Gay, Bisexual, Transvestite, Transsexual Women, Trans Men and Transmasculine People, other "trans" and/or gender-variant people and Intersex People) was set up. and linked to Department of Primary Care (DAB) of the São Paulo Municipal Health Department (SMS), with the aim of promoting public policies and establishing health care for the LGBTI population based on the principles of the SUS.	The aim of this document is to support Primary Care in welcoming and providing specific care for these populations, since it is the level of care that has the function of offering access to health, comprehensive care, longitudinality and coordination of care, with the aim of providing access to health. opportunity to knowing the individual's surroundings and potentially carrying out care oriented according to their family and community experience, through the cultural competence developed in working with the population of a given territory.
15	Jonathan Valles-Hernandez, et al, 2020	A descriptive study was carried out based on the review and analysis of published evidence from quantitative and qualitative studies, from 2005 to 2019, in English and	The results were classified according to the main access barrier in different analytical barrier categories: economic, organizational, geographical and cultural.

		Spanish.	
16	Morais, et al, 2020	Integrative review carried out in two databases in July. 2018. ENDNOTE® was used to systematize the articles.	The sample consisted of 18 articles. Three thematic categories were identified: "surgical techniques", "operative complications" and "psychosocial aspects".
17	Gabriela da Silva Santos, 2019	To this end, a qualitative methodology was used, guided by the 'case study' methodological strategy.	Throughout their careers, trans women and transvestites face the intolerance that permeates their paths to affirmation and self-recognition, whether through the control of their bodies or the sophisticated networks of exclusion from a 'cystem' orchestrated by the gender binary and heteronormativity.
18	Juliana Luiza Marazo, 2017	This research used the theoretical method, which consists of works consultation, scientific articles, as well as electronic elements dealing with the subject.	Transvestites and transsexuals are subjected to methods and procedures clandestine modeling, hormonal self-medication and liquid industrial silicone inoculation to adapt their bodies to the binarism imposed by heteronormativity, because they don't recognize the gender that was imposed by their biological sex at birth, thus altering their external image to the gender they feel they belong to.
19	José Jefferson, et al, 2021	Data was collected from trans people in Maceió through interviews conducted in October and November 2019.	There were gaps in health services regarding the treatment of trans people and a lack of public policies aimed at this public in Maceió.
20	Rodrigo Vellasco Duarte Silvestre, et al, 2018	This system uses specific probes for high and low oncogenic risk types. Subsequently, each positive sample will be evaluated to identify the specific viral type, using ROCHE's PCR plus specific type hybridization system, Linear Array HPV Genotyping Test, for the specific type identification of these infections for each viral type of high or low oncogenic risk so that the epidemiological data can be more complete.	In the 1,394 samples of the samples collected, 212 (15.2%) were identified as positive by the methodologies used, with 182 (85.8%) being infected with high-risk oncogenic types and 30 with low-risk types. With regard to the cytology of these samples, 970 had a cytological examination without alterations, and of these, 159 (16.4%) were positive for HPV, 142 (89.3%) for high risk and 17 (10.7%) for low risk.
21	Lucas Moreira Florido, et al, 2019	In PubMed, there were the following descriptors were used, transgender AND pap smear, 19 articles were found and selected 16. In LILACS, the following descriptors were used: transgender AND screening. 6 articles were found and 2 were selected.	The key point for improve screening is the implementation of content about trans men and contact with this population from an early age in the academic training of health professionals to enable greater knowledge and empathy on their part, allowing dignified and quality care for patients.
22	Mônica Angonese, et al, 2017	We conducted ethnographic research and analyzed Brazilian health and human rights documents.	The absence of the trans population in practices and discourses related to rights and reproductive health in general was verified, as well as their predominant invisibility in documents related to the transsexualization process and the rights of the lesbian, gay, bisexual, transvestite and transgender (LGBT) community.

23	Alice Duarte Paiva, et al, 2019	Literature review of 29 articles from the NCBI and SciELO databases, using English descriptors.	Sexual reassignment for transgender women uses hormones that can lead to breast cancer due to estrogen exposure without the counterbalance of progesterone.
24	Simone Monteiro, 2019	A bibliographical study was carried out using the hypothetical deductive method	The texts agree on the importance of public policies investing consistently and continuously in tackling the stigma and conditions of social exclusion that mark the daily lives of transvestites, trans women and trans men.
25	Francisco Chong Villarreal, 2020	The constant comparison method is used to form categories within the patterns found	The results highlight that the structural oppression of sexual practices and gender expressions increases with the exacerbation of material needs and for spiritual and psychological support.
26	Janaína Machado Sturza, et al, 2020	A bibliographical study was carried out using the hypothetical deductive method.	The (re)organization of a public health system that welcomes everyone without distinction, but without forgetting individualities, has become essential.
27	Daniela Soares Mariano, et al, 2020	The article was developed by surveying the literature in virtual publications related to transsexuality and Brazilian public health.	This article is a survey of data on the experience of the Transsexualizing Process in the SUS over the last 10 years, with the aim of pointing out advances and weaknesses.
28	Robert Davies, et al, 2017	Experience report	Data from the Youth Risk Behavior Surveillance System showed a decrease in teen suicide attempts in states that adopted same-sex marriage policies.
29	Bruna Pardine, et al, 2018	The research method used was bibliographic	The results point to the existence of constant psychological violence in the lives of this population through the non-recognition of their identities and their basic rights to use a name that represents them, use the appropriate bathroom with his identity as gender, health, education and employment.
30	Ana Lodi, et al, 2017	The methodology used in the research was a literature review and articles from the areas of sociology, history, philosophy and specialists in the field of medical and social sciences via searches in VHL Brazil, Scielo and Google Scholar, and for articles with the word "transgender".	This paper supports timely medical intervention to achieve gender/body congruence combined with affirmative mental health therapy, with an appropriate approach to minimize negative health outcomes and maximize positive future outcomes for transgender children.
31	Kelly Alves de Souza, 2020	Bibliographic research	There are no public policies for the inclusion and protection of these women in society in general.
32	Anna Caroline Bastos, et al, 2020	In order to construct this article and achieve the intended objectives, we used the topic: "The changes", which aims to show how difficult the difficulties encountered by a transgender person in their life are, through examples and bibliographical and documentary research.	After portraying the biggest problems that transsexuals .transsexuals face throughout their lives, it is worth pointing out that, after so many years in search of improvement and respect, they are gradually succeeding.

33	Salzman Todd A, et al, 2021	The focus of this essay is on the divisions that the new policy promotes around sex and sexualities and how the United States Conference of Catholic Bishops (USCCB) is promoting these divisions legally, theologically, anthropologically and ethically.	We conclude that in its teachings on homosexuality and its advocacy against the Equality Act and non-discrimination legislation, the USCCB promotes unjust discrimination against members of the LGBT community, violates human dignity and attacks the common good.
34	Maureen K. Flynn, et al, 2021	Participants were recruited through advertisements on social media sites (e.g. Facebook), Reddit and organizations serving gender minorities and 402 participants were included in the statistical analyses.	The results showed that both psychological flexibility and inflexibility moderated the relationship between 1) internalized transphobia and life satisfaction and
35			2) non-disclosure of gender identity and satisfaction with life.
36	Roberta Cristina Gobbi Baccarim, et al, 2020	Interviews were conducted with public health professionals in Curitiba/PR, covering their knowledge of transsexualities and transvestites, public health policies for transvestites and transsexuals, and their experiences of care.	It was observed that regulatory gender norms affect the practice of policies and care for trans people, making it difficult for them to access public health services
37	Lívia Karoline Morais da Silva, et al, 2017	The following categories of analysis were chosen: welcoming and promoting access to health through the social name; the social name as a tool for humanizing care; and the social name as a basis for making integrality a reality	If professionals make this right a reality, respecting it and providing the means to use it orally and in medical records and documents, it will make it easier to carry out health actions, enforcing the citizenship and health rights of these users.
38	Francisco Chong Villarreal, 2021	Using the constant comparison method to form categories with the patterns found.	The results show that the structural oppression of sexual practices and gender expressions increases as material needs and spiritual and psychological support worsen.

Source: survey data

VI. DISCUSSION OF THE RESULTS

6.1 Transphobia in healthcare: LGBT barriers to accessing health services

Transsexuality has a very peculiar characteristic that leads it to be considered a social phenomenon: it is marked by self-diagnosis and therapeutic self-prescription, that is, the subject self-identifies in a certain description - which they have seen appear in the media or seen someone say - and goes to the doctor asking for the "correction" that they have been told is appropriate (Jorge and Travassos, 2018, p.57). It is understandable that the purpose of this correction, in the case of transsexuals, is the marked disharmony between sex and gender, which sometimes causes unbearable suffering, stemming from the coercive force of gender over sex, suffering that drives them to demand that medicine intervene in the real body. (JORGE and TRAVASSOS, 2018, p.47)

The desire for numerous interventions along the body, in the case of transsexuals, is due to the search for passability - a term used to refer to the extent to which a transsexual man or woman "passes for" a cisgender man or woman - an individual who presents themselves to the world and identifies with their biological gender - and is a term debated in the transsexual community, since trans women and men do not "pass for" they "are" (Sam Winter, et al, 2016). However, for reasons of insecurity and fear of rejection, transsexuals seek the "perfect" appearance of the gender they identify with in order to be accepted by society (Jéssica Leite Serrano, et al, 2019).

When these standards are called into question, such as transsexuality, rejecting behaviours are conceived as a vicious circle, passed down from generation to generation and characterized as transphobia. Transphobia can be defined as the irrational

rejection, fear or intolerance of transsexuals (Pamela Suelen de Oliveira Reis, et al, 2021).

Trans men and women under the oppression of society's normative morality, judged as not belonging to the gender group they identify with, are regularly classified as "not normal" or "unnatural", which leads to an uncontrolled search for ways to change their physical appearance. Furthermore, social recognition is necessary for the self-acceptance and well-being of these individuals (Pablo Cardozo Rocon, et al, 2016). In this process, the health risks are immeasurable, as the desired aesthetic change is not understood as a public health service and the majority of this population does not have the financial resources to access private clinics (Dianna Schreiber Popadiuk, et al, 2017).

A large part of the transsexual population suffers from the lack of family acceptance of their gender identity, and as a result they are expelled from their families and homes. The job market for them is closed, with no guarantee of employability, favoring informal or clandestine work. Furthermore, this population is forced into prostitution as a means of survival (Fernando Scheller, 2017). The desire for a body that reflects their gender identity, coupled with the need to be perceived as such in prostitution, leads transsexuals to use high-risk resources, such as prostheses and silicone applications that are not regulated by ANVISA (National Health Surveillance Agency). Therefore, it is understood that the mental health and emotional balance of transsexuals is only possible by mitigating gender dysphoria in their own bodies (Monique Mendes, et al, 2020).

It is important to know what affects, afflicts and harms the health of the transgender population. In addition to biomedical and epidemiological information on the prevalence, risk and vulnerability of diseases, it is important to know this data in order to formulate public health policies aimed at the group, the implications of gender issues, the structuring of health services and the work of professionals, since these are the factors that directly interfere with access and guarantee the right to health of the transsexual population (Nizar Amin Shihadeh, et al, 2021).

It is also necessary to understand the cultural differences between the regions of Brazil, since (Pablo Cardozo Rocon, et al, 2019) report that "in the north/northeast, the transsexual category practically does not exist. Thus, it is common for transvestites to seek out the program in search of body changes that can include genital modification". As a result, there is a noticeable lack of medical care and monitoring for this population, especially in regions considered to be less developed. This scenario, unfortunately, is still present today, which is solidified by the fact that the life expectancy of Brazilian transsexuals is 35 years, half the national average (Cecília Barreto, et al, 2018).

A survey carried out in the United States in 34 municipalities with a sample of 877 respondents found that 86% of the participants were against transsexuality, reinforcing the view that transphobia is largely socially determined (Maureen K. Flynn, et al, 2021).

In addition, a study carried out by the Association of Gay, Lesbian, Bisexual and Transgender Parades in Brazil in 2006, with 846 members of the group, found that 67% had suffered discrimination because of their gender identity, and that 59% had experienced some kind of physical violence. Although these studies do not represent the entire population, they are an important indicator of the existence of transphobia, which permeates the daily lives of the LGBT population (Lucas Périco, 2021).

Transphobic discourses are present in the conduct and minds of health professionals. For some health workers, the LGBT population is a group of sick people, not worthy of formalizing marriages and adopting children; witnessing attitudes of affection between members of the group has aroused the repulsion of these workers (Stevão Rafael Fernandes, et al, 2018).

Inadequate conduct, embarrassment, prejudiced connotations or even verbal aggression on the part of health professionals in health units, generate losses in health reception and, consequently, in the demand for care. These attitudes can be experienced as situations of violence (sometimes silent, sometimes concrete) that can contribute to a shift away from caring for one's own body and the health of the transgender population (Secretaria Municipal da Saúde de São Paulo, 2020).

Faced with this reality, the group fears revealing their gender identity to health services when seeking assistance for their transsexualizing process, anticipating the negative impact that such an attitude can have on the quality of care (Jonathan Valles-Hernandez, et al, 2020). As a result of non-disclosure, the transsexual population is treated according to heterosexual and cis-gender standards, and is dissatisfied with the care they receive, because, in part, it does not meet their real needs or even desires (MORAIS, et al, 2020).

The presence of internalized transphobia in the LGBT population also seems to be another aggravating factor for not seeking services. Shame and fear of reprisals after revealing their gender identity have been associated with a number of problems among including

depression and anxiety, relationship problems, sexual compulsion and the use of psychoactive substances (Gabriela da Silva Santos, 2019).

In general, the existence of internal and external transphobia means that, in cases of illness, the population goes to clandestine services first, even at the risk of even more harmful results, such as the use of medications prescribed and marketed by unauthorized people. The transgender population turns to health facilities only when resolution is unsuccessful and they can no longer ignore the symptoms (Juliana Luiza Marazo, 2017). Self-medication allows diseases to appear, with the consequent search for units and emergency rooms, often considered the gateway to the system (José Jefferson, et al, 2021).

6.2 Implications of transsexuality on self-care and access to health services

Although the subject is growing in scientific circles, due to the invasion of the subject in the media, knowledge about access to health services by the transsexual population in general is a fundamental dimension for the formulation of appropriate public policies.

The demand for health services for transsexual men compared to transsexual women reveals a lower frequency of preventive and routine examinations, such as cervical and breast cancer prevention. Transgender men are ten times more likely not to have a pap smear and four times more likely not to have a mammogram (Rodrigo Vellasco Duarte Silvestre, et al, 2018).

The reduction in the frequency of Pap smears is justified by transsexual men in the way the test is carried out, as it can reveal the presence of self-reported masculine physical attributes and enable the identification of a gender identity that can be seen as deviant. A study of transgender men revealed negative experiences in gynecological clinics, finding inappropriate reactions and rejections from professionals (Lucas Moreira Florido, et al, 2019).

Another reason why transgender men don't seek sexual and reproductive health services is that they don't believe they run the risk of acquiring or are capable of transmitting sexual diseases, as they consider that this is only possible in heterosexual relationships and through promiscuity (Mônica Angonese, et al, 2017). Even so, these individuals have reduced protective factors for breast and ovarian cancer, especially those who do not wish or intend to become pregnant (Alice Duarte Paiva, et al, 2019).

In comparison, transgender women also have difficulty accessing health services. A study in Brazil revealed that transgender women have low demand for services and when they do seek them out, their medical needs are not met as a result of discriminatory attitudes on the part of professionals (Simone Monteiro, 2019). It is noteworthy that the AIDS epidemic has increased this population's search for these services, making LGBT people, in general, more likely to seek preventive care for situations that put them at risk of HIV infection, since there is a historical and cultural association between homosexuality/transexuality and HIV (Francisco Chong Villarreal, 2020).

Regarding the search for access to health information, a study carried out in Brazil with transgender participants revealed that the sources of information for this group are LGBT friends, magazines/books, websites and civil society organizations (Janaína Machado Sturza, et al, 2020). Among older transgender women, the main source of information is most often other transgender women or sexual partners, making the prevention of certain diseases seen as 'couple business' and not something that should be shared with a health professional, which increases susceptibility to illness (Daniela Soares Mariano, et al, 2020).

Improperly obtained information and failure to seek health care early favor the emergence of other problems. The connection with alcohol, tobacco and drug use, suicide attempts and a tendency to depression appear with high frequency in the transsexual population, as do problems related to sexual and reproductive health (Robert Davies, et al, 2017). Many transsexuals, because they do not reveal their sexual orientation and play a typical role within the gender to which they belong, are more likely to develop psychological disorders, especially young trans people, due to the difficulty they experience with social and family acceptance (Bruna Pardine, et al, 2018).

A survey of young LGBT people identified the need for greater sensitivity on the part of health professionals in an attempt to solve the problems of this population. Young LGBT people affirmed the importance of a more comprehensive look at the area of the worker in health promotion, in mediating conflicts, especially in the family sphere, and in reducing social homophobia and transphobia (Ana Lodi, et al, 2017).

Similar data is found in the elderly transsexual population, who experience major challenges and barriers in accessing health services to reveal their gender identity. Stigma is associated with the belief that ageing and transsexuality increase the risk of social isolation,

poor physical and mental health, cognitive impairment and mortality in the elderly population in general (Kelly Alves de Souza, 2020).

6.3 Professional training in health: deficits in care for the transgender population

The perception of transsexuality in the face of universal morality and the consequent rejection of trans men and women are some of the greatest difficulties for health professionals in dealing with trans patients. The criminalization and stigmatization of transsexuality are major barriers to providing access and use of services by health professionals (Anna Caroline Bastos, et al, 2020).

A survey carried out in the United States with 116 health students, 75% of whom were female, found that 8-12% believed that transsexuality should be punished; 5-12% of the students disliked gender and sexuality minorities; and 51-53% noted that transsexuality was against their religious beliefs (Salzman Todd A, et al, 2021). In England, out of a group of 137 students, 83% of heterosexual cis-gender women, 16% feel uncomfortable if they are responsible for caring for a trans woman (Maureen K. Flynn, et al, 2021).

Inexperience and/or a lack of professional training, capacity and conception during academic training can also be considered an obstacle for the group in question. Even so, the thematic approach inherent in gender and sexuality, which often goes against professional modesty, prevents satisfactory health care from being provided to the group (Rodrigo Borba, 2016).

Intervention strategies, such as continuing education, can be adopted to prepare health professionals for non-discriminatory care aimed at the LGBT group, guaranteeing the right to comprehensive care, as provided for in the legislation. Experiences with continuing education show satisfactory results (Roberta Cristina Gobbi Baccarim, et al, 2020). In Kenya, a 2-day training for health professionals provided information about transgender people, their sexual risk behaviors and their health needs. The post-training evaluation, 3 months after this intervention, found a reduction in prejudiced attitudes and an increase in the knowledge of these health professionals regarding the particular health of this population (Secretaria Municipal da Saúde de São Paulo, 2020).

In addition, there is a need to make available, in the training of health professionals, evidence-based clinical information regarding the process of health care for the transgender population. These requirements are: communication standards; understanding the relationship between health, illness and gender issues; a humanitarian approach to trans patients; and addressing the most common health problems (Rodrigo Borba, 2016). It is pertinent to reduce the difficulties of access to health services, as well as the violation of confidentiality and discrimination by professionals, by adopting these attitudes. Even health professionals criminalize transsexuality. Instead, they can be encouraged to provide a supportive and safe environment in which this minority can discuss their risk behaviors, sexuality and health problems (Lívia Karoline Morais da Silva, et al, 2017).

The universality of the right to health requires the proposal of strategies and specific attention, according to the singularities of the subjects who seek services, living up to the principle of Equity of the Unified Health System (Simone Monteiro, et al, 2019). This implies that social determinants, such as sexual orientation and gender identity, should be known and cultivated by health professionals. It is hoped that the problematization of transsexuality can advance, so that the LGBT population has its citizenship rights respected, especially in the field of integrated health (Francisco Chong Villarreal, 2021).

VII. FINAL CONSIDERATIONS

Based on the data obtained, it was possible to start reflecting on the fragility that still exists between transsexuality and the care provided by health services. Despite the presence of qualitative studies, and considered a limitation of this review due to the subjective nature of its methodological approach, the review highlights the prejudice and discrimination suffered by the LGBT population, especially transsexuals, in accessing quality health services.

LGBT people find it difficult to communicate with health professionals, as well as fearing assumptions about their gender identity and embarrassing situations when expressing their transsexuality, due to the transphobia present in the conduct of professionals.

Exclusion and marginalization in health services implies a reduction in care and consequent search for care, contributing to the detour of these patients from caring for their own bodies and reducing the chance of developing educational and preventive health work.

It is therefore necessary to ensure that, in addition to providing qualified and equipped health services, there are trained professionals who are free of discriminatory attitudes in this area. They must be able to analyze their patients' state of health, taking into account

the health, social and cultural context in which they live. To this end, new research on the subject could provide a broader discussion and generate favorable changes in health care for transsexuals.

To this end, important measures include: introducing this topic into the undergraduate curricula of health professionals; carrying out training with professionals already working in the field; monitoring the implementation of laws that deal with social transphobia; and developing empowerment strategies for the LGBT population, so that they can act in the relentless pursuit of their rights, making themselves visible as subjects of their own history.

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Epidemiological analysis of the mortality profile from Cerebrovascular Disorders in the Northern region of Brazil in the last decade

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Keywords*— *Cerebrovascular Disorders, Epidemiology, Public Health.

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***Abstract*— *Introduction: Cerebrovascular Diseases encompass several pathologies with clinical manifestations resulting from the interruption of cerebral blood flow, which can manifest in an ischemic form, generally linked to circulation obstruction, or in a hemorrhagic form, when there is vascular rupture. Given the widespread occurrence of deaths and permanent sequelae that such diseases generate, investigation and understanding of them become essential. Objectives: To analyze the epidemiological profile of hospital mortality due to Cerebrovascular Diseases in the northern region of Brazil, from January 2014 to December 2023. Methods: This is an observational and descriptive study, which provided records of deaths due to cerebrovascular diseases in individuals from the Northern region of Brazil, between January 2014 and December 2023, obtained through the Department of Informatics of the Unified Health System (DATASUS), using the variables color/race, age group and sex to define a mortality profile. Results: The data collected demonstrated the occurrence of 21,735 deaths due to cerebrovascular diseases in the region in question during the period considered, a value that corresponds to 6% of deaths nationally.*

Regarding the profile of these patients, it should be noted that 52.7% were male, 71.6% were over 60 years old and 60% declared themselves mixed race. Finally, 95% occurred urgently and 82% had their care regimen ignored. Conclusion: Thus, it is evident that cerebrovascular disorders predominate in the male population in a disadvantaged socioeconomic situation, especially elderly, brown men and possibly with restricted access to health surveillance and primary prevention mechanisms, such as encouraging and subsidizing healthy eating and physical activity. Therefore, the need for preventive actions is evident in order to guarantee the well-being and longevity of northern patients.

Resumo— *Introdução: As Doenças Cerebrovasculares abrangem diversas patologias com manifestações clínicas resultantes da interrupção do fluxo sanguíneo cerebral, podendo manifestar-se de forma isquêmica, geralmente ligada à obstrução da circulação, ou de forma hemorrágica, quando há ruptura vascular. Dada a ampla ocorrência de mortes e sequelas permanentes que tais doenças geram, a investigação e a compreensão das mesmas tornam-se essenciais. Objetivos: Analisar o perfil epidemiológico da mortalidade hospitalar por Doenças Cerebrovasculares na região Norte do Brasil, no período de janeiro de 2014 a dezembro de 2023. Métodos: Trata-se de um estudo observacional e descritivo, que forneceu registros de óbitos por doenças cerebrovasculares em indivíduos de região Norte do Brasil, entre janeiro de 2014 e dezembro de 2023, obtido por meio do Departamento de Informática do Sistema Único de Saúde (DATASUS), utilizando as variáveis cor/raça, faixa etária e sexo para definir perfil de mortalidade. Resultados: Os dados recolhidos demonstraram a ocorrência de 21.735 óbitos por doenças cerebrovasculares na região em questão no período considerado, valor que corresponde a 6% dos óbitos a nível nacional. Quanto ao perfil desses pacientes, destaca-se que 52,7% eram do sexo masculino, 71,6% tinham mais de 60 anos e 60% declararam-se pardos. Por fim, 95% ocorreram de forma urgente e 82% tiveram seu regime de cuidados ignorado. Conclusão: Assim, evidencia-se que os distúrbios cerebrovasculares predominam na população masculina em situação socioeconômica desfavorecida, especialmente homens idosos, pardos e possivelmente com acesso restrito à vigilância em saúde e aos mecanismos de prevenção primária, como incentivo e subsídio à alimentação saudável e à atividade física. Portanto, fica evidente a necessidade de ações preventivas para garantir o bem-estar e a longevidade dos pacientes do Norte.*

I. INTRODUÇÃO

As doenças cerebrovasculares (DCVs) continuam a ser um dos maiores desafios de saúde pública no Brasil, figurando entre as principais causas de morte e incapacidade no país. Dentro desse grupo de condições, o Acidente Vascular Cerebral (AVC), tanto na forma isquêmica quanto hemorrágica, destaca-se como a manifestação mais prevalente (Reis e Chaoubah, 2023). A incidência e a mortalidade por AVC, no entanto, apresentam variações significativas entre as diferentes regiões do país, refletindo desigualdades estruturais e socioeconômicas. Na região Norte do Brasil, essas disparidades são particularmente graves, revelando uma realidade de maior vulnerabilidade em relação ao restante do território brasileiro (McBenedict et al., 2023).

A região Norte enfrenta desafios únicos no que se refere à saúde pública, sendo marcada por uma infraestrutura de saúde deficiente, dificuldade de acesso a serviços especializados e a presença de altos índices de fatores de risco modificáveis, como hipertensão, diabetes e sedentarismo. Enquanto as regiões Sul e Sudeste avançaram no controle e no tratamento das DCVs, com a

implementação de unidades de tratamento especializado e o uso de tecnologias de ponta, a região Norte ainda sofre com a escassez de profissionais de saúde, longas distâncias entre centros urbanos e áreas rurais, e a falta de investimentos suficientes em saúde (Rocha et al., 2021). Além disso, a falta de conscientização sobre os sintomas de AVC entre a população agrava o quadro, atrasando o diagnóstico e, consequentemente, o tratamento adequado (Bernal et al., 2020).

Além dos fatores de risco modificáveis, é importante ressaltar o impacto dos fatores de risco não modificáveis, como idade, sexo e cor da pele, no perfil epidemiológico das DCVs. Na região Norte, populações mais envelhecidas, homens em faixas etárias mais avançadas e grupos étnicos, como pardos e indígenas, apresentam maiores vulnerabilidades a essas condições. Esses fatores não modificáveis desempenham um papel crucial na mortalidade por DCVs e precisam ser considerados ao analisar o cenário regional, pois influenciam significativamente os desfechos clínicos e as estratégias de prevenção (Reis e Chaoubah, 2023).

II. METODOLOGIA

Trata-se de um estudo observacional, subtipo descritivo, de cunho epidemiológico realizado a partir de dados secundários obtidos no Departamento de Informática do Sistema Único de Saúde (DATASUS) em relação ao perfil de mortalidade hospitalar por etiologias cerebrovasculares na região norte do Brasil, no período de janeiro de 2014 a dezembro de 2023. No presente trabalho, foram considerados os valores absolutos e relativos dos óbitos na região de interesse e em seus estados, assim como nas demais regiões brasileiras para fins comparativos.

Subsequentemente, as variáveis “sexo”, “faixa etária”, “cor/raça” foram correlacionadas com as informações de óbitos pré-selecioandas para a definição de um perfil de mortalidade na região. Dados complementares como o caráter de atendimento (urgência e eletivo) e o regime de atendimento (rede pública ou privada) desses pacientes também foram incluídos no estudo. Com o intuito de simplificar a análise e apresentação de dados referentes à faixa etária, a mesma foi padronizada em 3 grupos: pediátrica (0 a 19 anos), adulta (20 a 59 anos) e geriátrica (acima de 60 anos).

Tendo em vista a proposta de ampla investigação de distúrbios vasculares em campo encefálico, a delimitação etiológica na plataforma ocorreu por meio da seleção simultânea dos itens disponíveis que enquadraram-se no eixo proposto: “Acidente vascular cerebral isquêmico transitório”, “Hemorragia intracraniana”, “Infarto cerebral”, “Acidente vascular cerebral não especificamente hemorrágico ou isquêmico” e “Outras doenças cerebrovasculares”.

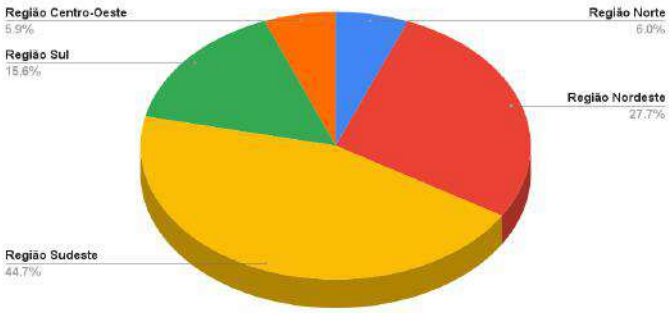
Por fim, os dados obtidos foram organizados em planilhas usando o programa Microsoft Excel 2016, posteriormente, foram elaborados gráficos utilizando os recursos do mesmo programa para otimizar a apresentação dos resultados. Definiu-se o modelo gráfico em linha para a demonstração dos dados ao longo dos anos considerados, enquanto o gráfico em porções (“em pizza”) expõe os valores cumulativos da série histórica considerada.

Vale ressaltar que por se tratarem de dados secundários e públicos, a pesquisa não precisou ser submetida à análise e aprovação do comitê de ética, de modo que encontra-se em conformidade com a Resolução 466/2012, a qual regula a pesquisa com seres humanos no país.

III. RESULTADOS

A partir dos dados obtidos, observou-se um total de 21.735 óbitos causados por doenças cerebrovasculares na região norte do Brasil, correspondendo a cerca de 6% das mortes a nível nacional por tais etiologias no período considerado. Em uma distribuição comparativa com as demais regiões, ela ocupa a penúltima colocação, com valores bem próximos aos da região Centro-Oeste (gráfico 1).

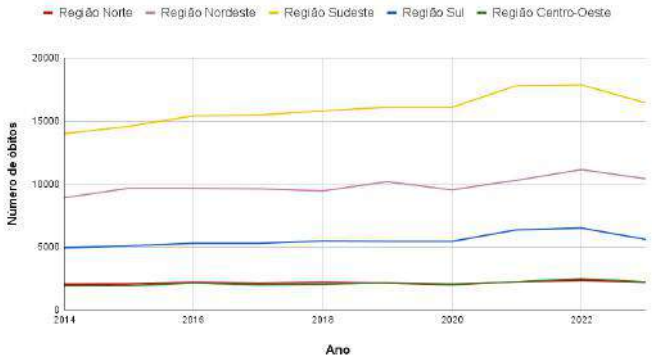
Gráfico 1: Total de óbitos por Doenças Cerebrovasculares nas regiões do Brasil (2014-2023).



Fonte: *Autores, 2024.*

A média anual regional é cerca de 2.173 mortes e ao longo da década definida notam-se discretas variações, de forma que esse comportamento é quase linear graficamente (gráfico 2).

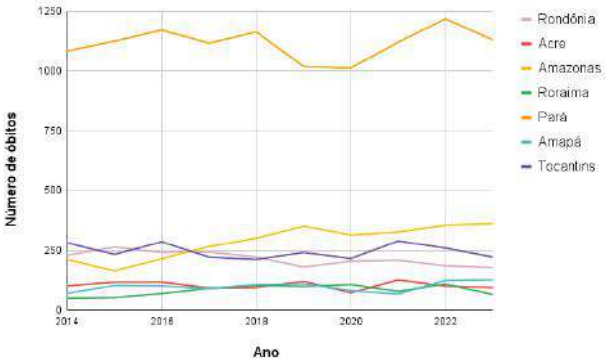
Gráfico 2: Óbitos por Doenças Cerebrovasculares nas regiões do Brasil ao longo da última década (2014-2023).



Fonte: *Autores, 2024.*

A respeito dos sete estados que integram a região, o Pará é o que mais se destaca com valor total de 11.245 mortes, equivalente a 51,7% do número de óbitos da região, estando significativamente acima dos demais em toda a série histórica estudada, com valor máximo em 2022 (1.219) e mínimo em 2020 (1.013). O estado do Amazonas aparece em segundo lugar com 2.877 óbitos e o Tocantins em terceiro com o valor de 2.473 (gráfico 3).

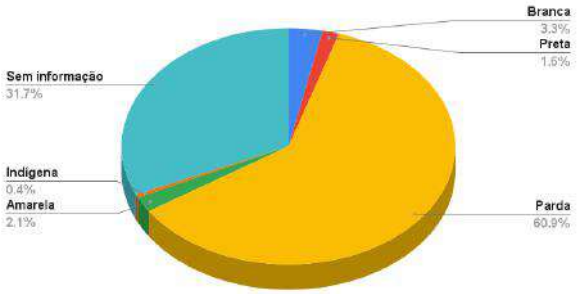
Gráfico 3: Óbitos por Doenças Cerebrovasculares nos estados da Região Norte ao longo da última década (2014-2023).



Fonte: *Autores, 2024.*

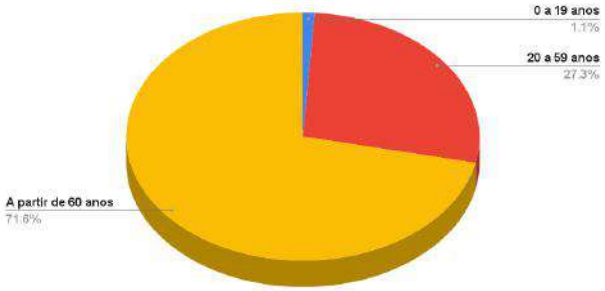
No que se refere ao perfil de mortalidade traçado, é possível apontar o predomínio da etnia parda com mais de 60% dos casos, seguida por uma parcela de 31,7% sem informação de autodeclaração (gráfico 4); do mesmo modo é notório o maior acometimento da população idosa com valor relativo de 71,6%, seguida de 27,3% composto por adultos e pouco mais de 1% composto por indivíduos até 19 anos (gráfico 5); por fim, o sexo masculino mostou discreta prevalência com 52,7% em comparação aos 47,3% do sexo feminino (gráfico 6).

Gráfico 4: Distribuição étnica dos óbitos por Doenças Cerebrovasculares na Região Norte do Brasil (2014-2023).



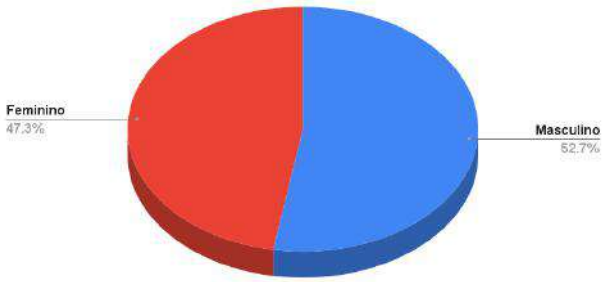
Fonte: *Autores, 2024.*

Gráfico 5: Distribuição por faixa etária dos óbitos por Doenças Cerebrovasculares na Região Norte do Brasil (2014-2023).



Fonte: *Autores, 2024.*

Gráfico 6: Distribuição por sexo dos óbitos por Doenças Cerebrovasculares na Região Norte do Brasil (2014-2023).

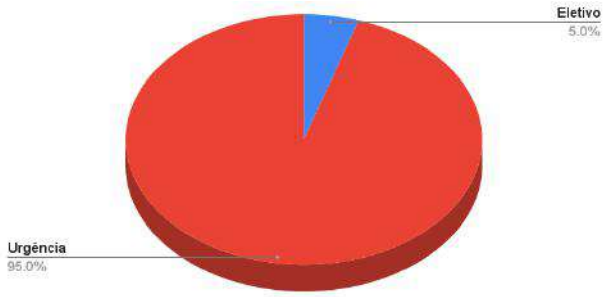


Fonte: *Autores, 2024.*

Em última análise, as informações complementares de atendimento evidenciaram a

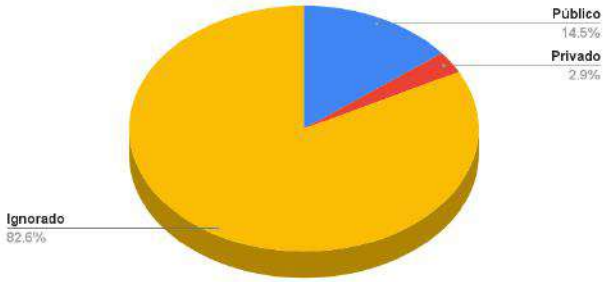
significativa superioridade do caráter de urgência com 95% (gráfico 7), ao passo que o regime de atendimento foi ignorado em mais de 82% dos casos, seguido por 14,5% caracterizados como setor público (gráfico 8).

Gráfico 7: Distribuição por caráter de atendimento dos óbitos por Doenças Cerebrovasculares na Região Norte do Brasil (2014-2023).



Fonte: *Autores, 2024.*

Gráfico 8: Distribuição por regime de atendimento dos óbitos por Doenças Cerebrovasculares na Região Norte do Brasil (2014-2023).



Fonte: *Autores, 2024.*

IV. DISCUSSÃO

As disparidades geográficas e socioeconômicas desempenham um papel central na mortalidade por doenças cardiovasculares (DCVs). Indivíduos pertencentes a grupos de status socioeconômico mais baixo apresentam taxas de mortalidade significativamente superiores, especialmente em países de baixa e média renda. Tal realidade está ligada à falta de acesso a cuidados preventivos de saúde e à infraestrutura inadequada para o atendimento de emergências (Dantas et al., 2020). Além disso, em áreas rurais, as taxas de mortalidade tendem a ser mais elevadas em comparação às zonas urbanas, devido à escassez de especialistas, como neurologistas, e à falta de tecnologias avançadas, como a trombectomia (Dutra et al., 2021).

A idade constitui um dos fatores de risco mais fortemente associados à ocorrência de DCVs. À medida que a população envelhece, o risco de desenvolvimento dessas enfermidades aumenta de forma exponencial, fenômeno igualmente observado na região Norte, onde a proporção de idosos tem crescido nos últimos anos. No entanto, as características demográficas dessa região apresentam nuances específicas, como uma população relativamente mais jovem em comparação a outras regiões do país, o que pode influenciar o perfil epidemiológico das mortes por DCVs (Moreira et al., 2021).

Outro fator de destaque no contexto das DCVs é o sexo. Estudos indicam que essas doenças afetam homens e mulheres de maneira diferenciada. Embora os homens apresentem maior risco de acidente vascular cerebral (AVC) em idades mais jovens, as mulheres tendem a sofrer desfechos mais graves, além de exibirem maiores taxas de mortalidade após a menopausa. Na região Norte, essas diferenças de gênero podem ser intensificadas pela falta de acesso adequado aos serviços de saúde e pela escassez de campanhas de conscientização direcionadas especificamente para cada sexo (Mansur et al., 2022).

A cor da pele também se revela um importante determinante não modificável no perfil epidemiológico das DCVs. Diversos estudos demonstram que populações não brancas, especialmente negros e pardos, apresentam maior risco de desenvolvimento dessas doenças, tanto por fatores socioeconômicos e de acesso à saúde quanto por predisposições genéticas (Javed et al., 2022). Na região Norte, onde há uma significativa proporção de pessoas pardas e indígenas, a influência da cor da pele sobre o risco de DCVs merece uma atenção especial. Barreiras ao atendimento adequado e discriminação institucional podem agravar as desigualdades no cuidado dessas populações, resultando em taxas de mortalidade mais elevadas (Wassink et al., 2017).

A pandemia de COVID-19 também impactou significativamente a mortalidade por doenças cerebrovasculares nos últimos anos. A crise sanitária agravou as disparidades preexistentes no acesso aos cuidados de saúde, sobretudo entre as populações mais vulneráveis. Pacientes infectados pelo vírus, especialmente aqueles com comorbidades preexistentes, apresentaram maior risco de eventos cerebrovasculares, contribuindo para o aumento temporário na mortalidade associada às DCVs durante os picos da pandemia. A sobrecarga dos sistemas de saúde e a hesitação dos pacientes em buscar atendimento emergencial também agravaram esse cenário (Bass et al., 2021).

V. CONCLUSÃO

As Doenças Cerebrovasculares têm se tornado cada vez mais prevalentes entre as doenças

cardiovasculares, resultando em um aumento global na morbimortalidade. Embora tenha havido uma redução geral nos óbitos causados por acidente vascular cerebral (AVC), graças às intervenções nos fatores de risco, especialmente os modificáveis, a região norte do Brasil ainda apresenta índices elevados de mortalidade por essas doenças. Para reduzir essa taxa de mortalidade, é crucial melhorar as práticas preventivas, com foco na identificação precoce dos indivíduos com fatores de risco. Conhecer o perfil epidemiológico dos óbitos por doenças cerebrovasculares da população nortista é essencial para direcionar as ações preventivas primárias e, assim, diminuir a taxa de mortalidade de DCVs e as complicações associadas ao AVC.

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Optimization of an Energy Recovery Circuit for a Low-Voltage Lighting System

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***Keywords*— transistor, coil, ferrite, simulation, primary, diode.**

***Abstract*—** *This work is devoted to the study of the physical properties of a circuit that allows both the last remaining charges of a pile or a accumulator yes cells unique to be used in other devices and to save energy stored in a new battery and all this in the lighting domain . The corresponding device is made from a transistor, a resistor and a coil. The coil is made up of a standard ferrite core with two windings of which the primary contains 34 turns and the secondary, 58 turns. Most components are local components. The study is based on the Proteus simulation software. The experiment of the device consists of comparisons of the energy consumed by an electroluminescent diode without the designed circuit and with this circuit to see its performance. In particular, the circuit can use a very low voltage of about 0.37V and can power the electroluminescent diode for a week without interruption if it is powered by a R6S/1.5V battery.*

I. INTRODUCTION

From time immemorial, energy has always been of great importance to man. Aside from their curiosity, this is one of the reasons why certain scientists research energy.

In each country, the energy needs of each individual do not cease to grow over the course of these last decades and their dependence, among others, on electrochemical storages is increasing.

Since its first appearance, the manufacture of batteries is becoming more and more frequent and its use is becoming more and more important. The presence of batteries is felt que ce soit en ville et que ce soit à la campagne. However, batteries contain heavy metals (mercury, lead, cadmium, zinc, nickel) but also other chemical species (carbon, manganese, etc.) human health.

In effect, one of the most toxic, most polluting and richest in chemical elements is the used battery. However, the implementation of measures to control used batteries is still insufficient, even non-existent, in developing countries such as Madagascar.

Faced with this sad reality, it is the duty of each citizen to sensitize the consumers and seek adequate solutions to these problems.

This article titled OPTIMIZATION OF AN ENERGY RECOVERY CIRCUIT FOR A LOW VOLTAGE LIGHTING SYSTEM aims to propose a circuit capable of both extracting the remaining charges from used batteries in order to revalorize them in the form of radiant energy and to save the use of new batteries from for lighting purposes.

The scientific interest of this research consists later to reuse this form of energy to reduce human waste and pollution and to satisfy part of our lighting needs in an economic manner.

II. METHODOLOGY

2.1 Junction diode

2.1.1. Description

A junction diode is a nonlinear electronic dipole that contains a metal, a P-type semiconductor, and another N-type semiconductor.

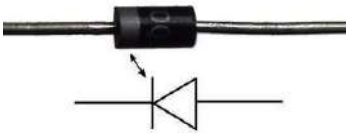

Fig. 3: Schematic representation of a junction diode.

There are two types of polarization for the diode:

- The polarization directly;
- The polarization in reverse.

2.1.2. Direct polarization

The direct polarization consists of introducing a current "I" to the positive pole of the diode, starting from point "A" and heading towards point "C".

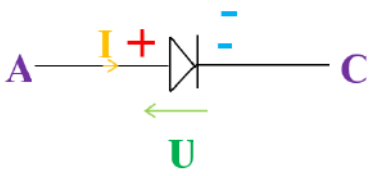

Fig.1. Direct polarization of a diode.

2.1.3. Reverse polarization

The reverse polarization consists on the other hand of introducing a current "I" to the negative pole starting from point "C" and directed towards point "A".

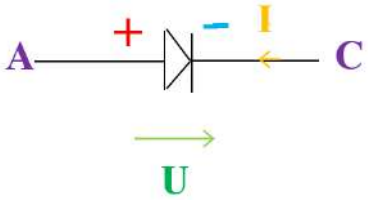

Fig..2. Reverse polarization of a diode.

2.2 Electroluminescent diode

2.2.1. Definition, [12]

An electroluminescent diode (LED) is a device optoelectronics capable of emitting light when it is traversed by an electric current. Unlike a classic diode, it only reacts if the polarization is in the forward direction.

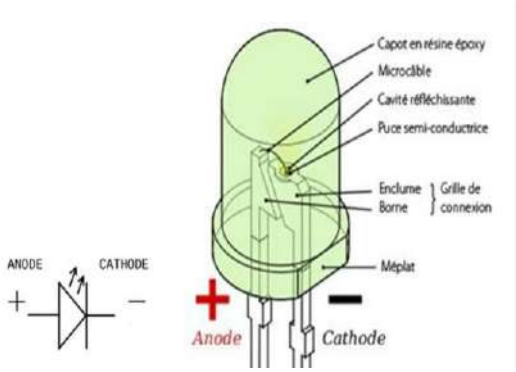

Fig. 3. Schematic and structural representation of an LED.

2.3. Transistor

2.3.1. Description

A transistor is an electronic device that is found in several applications namely oscillators, converters, microcontrollers, microprocessors, switches, current amplifiers, voltage amplifiers, power amplifiers, etc. Or, there are several types of transistor according to their structure.

Table 1: Types of transistors according to their structure.

Component	Order	Application type	Intensity maximum	Band passing
Bipolar	Current	Amplification, commutation	10 A	0 →1 GHZ
MOS, FET, JFET, MOSFET	Tension	Commutation	5 A	0 →10 MHZ
IGBT	Current	Power electronic commutation	200 A	0 →1 MHZ

2.3.2. Bipolar transistors, [14]

A bipolar transistor is made in a single crystal with three different doping zones namely the base "B", the emitter "E" and the collector "C":

- The transmitter "E" is heavily doped. Its role is to inject electrons into the base. It is identified by an arrow that indicates the direction of the current in the junction between base and collector.
- The "B" base is weakly doped and very thin. It transmits most of the electrons coming from the emitter to the collector.
- The collector "C" collects the electrons that come from the base of its name.

According to the mounting sense, we can have two types of bipolar transistor referring to the PN junctions (diodes), one of which is polarized directly and the other, inversely:

- An NPN transistor (two negative terminals and one positive terminal); A PNP transistor (one negative terminal and two positive terminals).

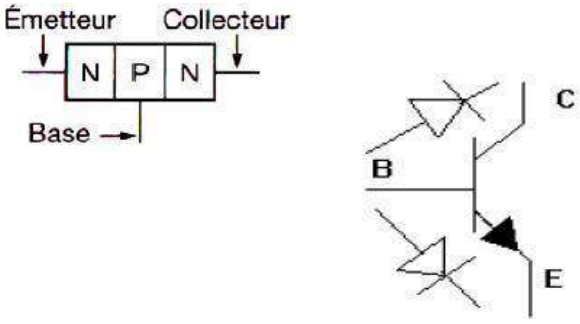

Fig.4. Schematic representation of an NPN transistor.

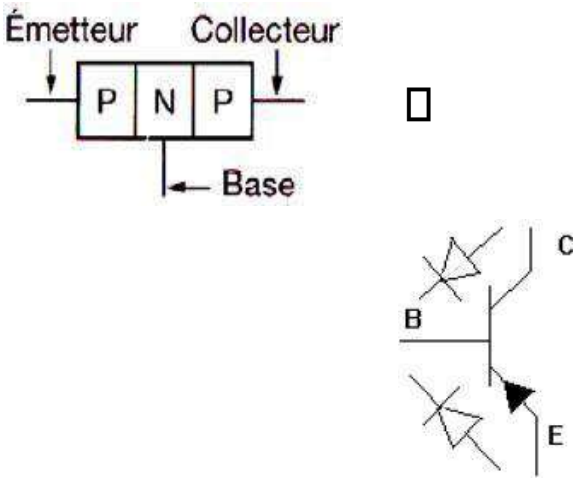

Fig.5. Schematic representation of a PNP transistor.

2.3.3. Operating regime

The purpose of the polarization of the junctions is to fix the values of the voltages UBE, UBC and the currents IC, IB to impose the localization of the points and to know the operating regime of the transistor in the network.

Table 2: Mode of operation of the bipolar transistor.

Voltage of junctions		Polarization of junctions		Operating regime
U_{BE}	U_{BC}	BE	BC	
Positive (+)	Positive (+) $U_{BE} > U_{BC}$	Direct	Direct	Saturé Direct (SD)
	Positive (+) $U_{BE} < U_{BC}$	Direct	Direct	Saturated Inverse (SI)
	negative (-)	Direct	Inverse	Normal Direct (ND)
negative (-)	Positive (+)	Inverse	Direct	Inverse Normal (NI)
	negative (-)	Inverse	Inverse	Blocked

At the saturation point, the transistor is equivalent to a closed switch while at the blocking point, the transistor is equivalent to an open switch.

The fundamental relationships between the three doping zones are given by:

$$I_C = \beta * I_B$$

$$UBC = UBE + UEC$$

with:

β, the amplification gain;

I_C, the current intensity at the terminal of the collector;

I_B, the current intensity at the terminal of the base;

I_E, the current intensity at the terminal of the transmitter;

U_{BC}, the tension at the terminal of BC junctions; U_{BE}, the voltage at the terminal of

BE junctions; EC , the voltage at the terminal of the EC junctions.

2.4. Resistance

2.4.1. Definition, [15]

Resistance is un electronic component don't the main role is to oppose more or less to the circulation du electric current .

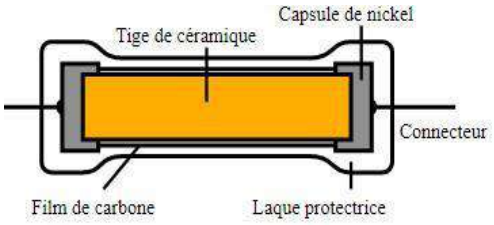

Fig. 6. Detailed structure of a resistance.

2.4.2. Ohm's Law , [16]

Resistance is linked to notions of resistivity and of electrical conductivity . It is designated by the letter "R" et son unit of measure is the ohm of the "Ω" symbol. Ohm's law is defined from these magnitudes such that:

$$U = R * I \quad (18)$$

With:

U , the tension;

R , the resistance;

I , the current intensity.

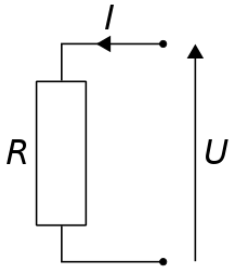

Fig.7. Schematic representation of a resistor.

2.4.3. Joule effect, [17]

The Joule effect is responsible for the dissipation of energy in the form of warmth in an electrical component. This production of heat is sometimes a desired effect (heating resistance) and sometimes a harmful effect (loss of energy due to the Joule effect). This property bears the name of the Joule effect and the energy dissipated between two instants t1 and t2 is written:

$$Q = R * I^2 * \int_{t_1}^{t_2} dt \quad (19)$$

2.5. Coil

2.5.1. Description, [18]

A coil is an electronic component made up of a coil of conductive wire around a core. It is diagrammed in an electric circuit according to Fig. 11.

Fig. 8. Schematic representation of a coil, [19]

A core is the space in the middle of these windings or turns. It can be empty or include a piece of material favoring electromagnetic induction, in order to increase the value of the inductance.

2.5.2. Classification of magnetic materials, [20]

There are terrestrial substances that have magnetic properties and can therefore become magnetized.. However, these magnetic properties are not equal for all these materials. Some of these are due to the rotation of electrons on themselves in the atom. This phenomenon is called "spin" and causes a magnetic moment.

The magnetization M is defined in function of the excitation field H and the magnetic susceptibility χ_m of the environment. It can be written in the following form:

$$M = \chi_m * H \quad (22)$$

The magnetic induction B is defined by:

$$B = \mu_0 * H \quad (23)$$

The materials can be classified into three categories according to their magnetic properties, as shown in Fig.9:

- Diamagnetism: the magnetic susceptibility is generally very small. Therefore, the diamagnetic materials are weakly magnetic in the opposite direction to the magnetizing field. Their magnetization ceases as soon as the magnetizing field is suppressed. Example: gold, silver, copper , zinc.
- Paramagnetism: magnetic susceptibility is small. Therefore, the paramagnetic materials are weakly magnetized in the direction of the magnetizing field. Their magnetization ceases as soon as the magnetizing field is

suppressed. Example: aluminum, platinum, manganese, air, oxygen, etc.

- Ferromagnetism: the magnetic susceptibility is very large. Therefore, ferromagnetic materials can be strongly magnetized. Their magnetization persists plus or minus when the magnetizing field is suppressed. Examples: cobalt, nickel, iron , steel , ferrite, martensitic , etc.

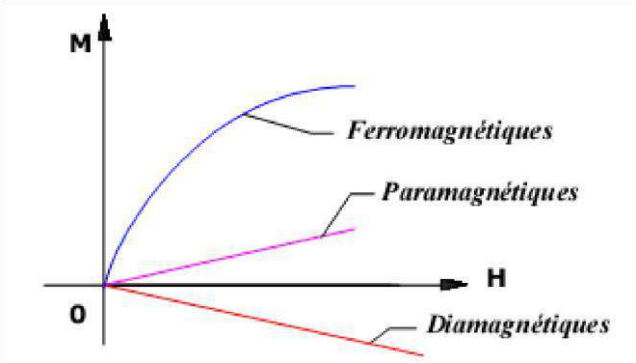

Fig. 9. Illustration of the magnetic behavior of substances .

2.5.3. Power transformer, [21]

The conversion of electrical energy makes use, in general, of two types of physical phenomena:

- Electrical phenomena associated with current;
- Magnetic phenomena associated with magnetic flux.

A power transformer is a static device that transfers electrical energy thanks to electromagnetic induction. For a transformer, two windings are at least necessary to be able to modify the level of the input signal without modifying the frequency.

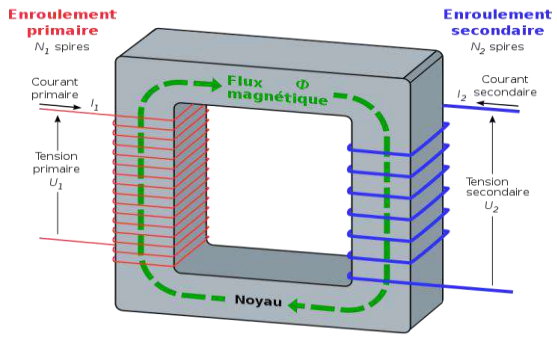

Fig. 10. Diagram of a power transformer with two windings, [22].

Posted by:

Φ, the magnetic flux generated in the core

N_1, the number of turns of the primary winding;

I_1, the intensity of the current that crosses the primary conductor;

U_1, the voltage at its terminals;

N_2, the number of turns of the secondary winding;

I_2, the intensity of the current that crosses the secondary conductor; U_2, the voltage of its terminals.

The circulation of the current through the primary winding generates a variable magnetic flux in the core such that:

$$\Phi = B*S \quad (24)$$

The magnetizing force is expressed as follows:

$$H = \frac{N*I}{l} \quad (25)$$

The transformer is at no load when the secondary winding has not been connected to a receiver but open. Thus, the flux variation induces a voltage in the secondary winding but does not flow any current. The primary winding behaves like a simple inductance that opposes the passage of the current.

The transformer works in charge when a receiver is connected to the output of the secondary winding. In this case, the variation in flux induced in the secondary winding generates another current which creates a magnetic field opposite to the field produced by the primary. In the end, there is perfect equality between the power generated by the secondary and the power consumed by the primary winding.. From the equality of apparent powers, we obtain:

$$P1 = P2 \quad (26)$$

With:

P 1, the power consumed by the primary winding;

P 2, the power generated by the secondary winding.

Thus :

$$U_1 * I_1 = U_2 * I_2 \quad (27)$$

If the tension applied at the entrance is lower than the cell recovered at the exit, the transformer works as an elevator, in the opposite case, as a step-down transformer.

And if we suppose that the number of turns of the primary compartment is higher than that of the

secondary compartment, we obtain a voltage reducer and the previous relation can then be written by:

$$\frac{[N_2]}{[N_1]} = \frac{[U_2]}{[U_1]} = \frac{[I_1]}{[I_2]} \quad (28)$$

On the other hand, if the number of turns of the primary compartment is lower than that of the secondary compartment, a voltage riser is obtained and the relationship becomes:

$$\frac{[N_2]}{[N_1]} = \frac{[U_2]}{[U_1]} = \frac{[I_1]}{[I_2]} \quad (29)$$

III. RESULTS

3.1. Simulation of the direct supply of an LED without device.

The various components of the circuit in the presence of the device require a resistor, an electroluminescent diode, a bipolar transistor of the NPN type reference 2N2222 and a coil with two windings. Among other things, we need essentially three (3) other additional components apart from the others we saw previously. The simulation of the complete circuit is visualized on Fig. 11.

When we simulated the circuit in the presence of the prototype, we noticed that the electroluminescent diode does not shine below an input voltage of 2.20 V. The minimum threshold voltage remains the same so that the electroluminescent diode can emit of the light. For the output voltage at the level of the diode, we found that the voltage collected still remains equal to that of the input voltage generated by the battery. Here, the transformer reacts neither as a tension reducer, nor as a tension rectifier.

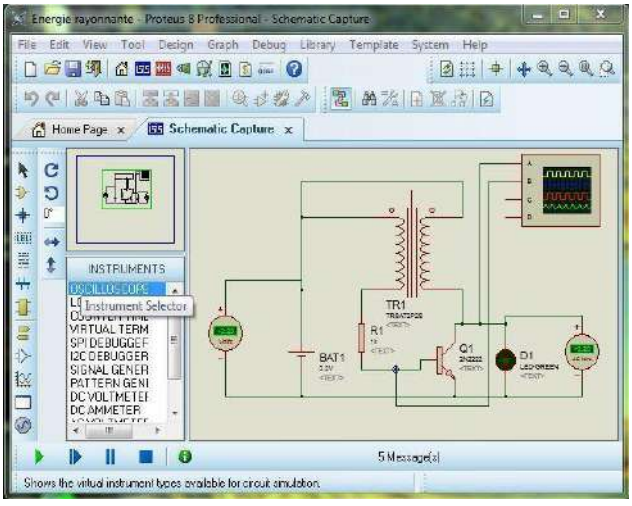

Fig. 11. Simulation of the circuit in the presence of the prototype.

When we visualized certain curves in the oscilloscope as the shape of the tension curve on the base of the transistor and the cell at the entrance of the electroluminescent diode, they are identical. However, the shape of the voltage curves changes when we change the resistance of each winding to be equal to 1 μΩ(see Fig. 13) and then to 1m (see Fig. 20). The shape of the curves obtained seems to be a function of the resistances of the respective windings. The signal is alternative to the output of the coil.

For the diagrams of the voltage curve, the yellow curve shows the voltage received by the diode at its input, while the blue curve shows the voltage at the base of the transistor (see Fig. 12 and Fig. 13) .

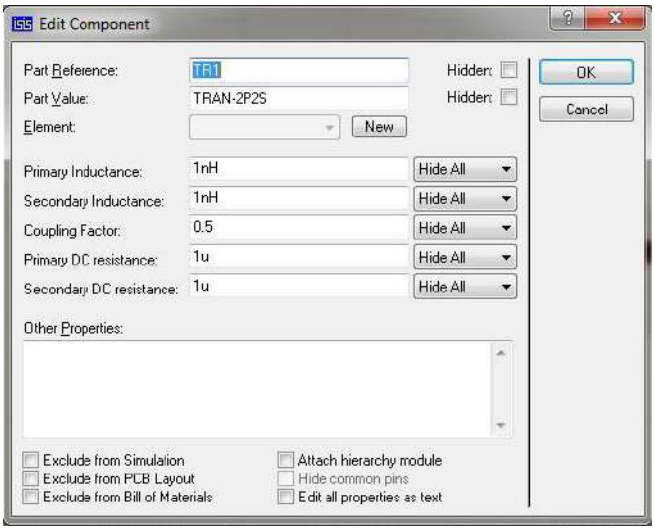

Fig. 12. Adjustment of the resistance of the respective windings of the transformer for 1 μΩ.

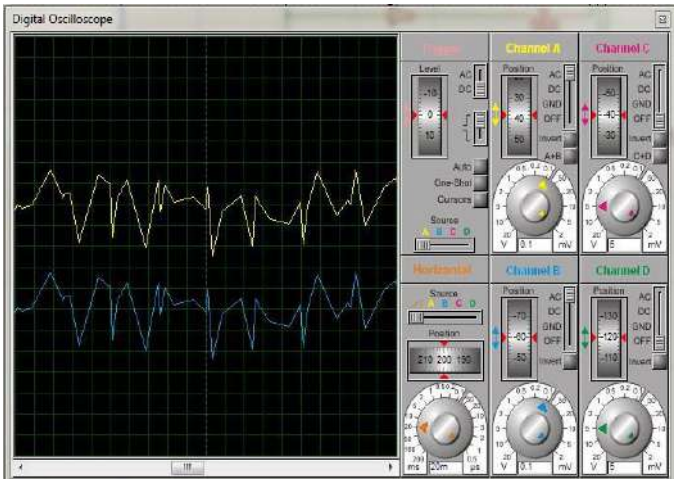

Fig. 13: Voltage curve at the level of the electroluminescent diode and the base of the transistor for a resistivity of 1 μΩ.

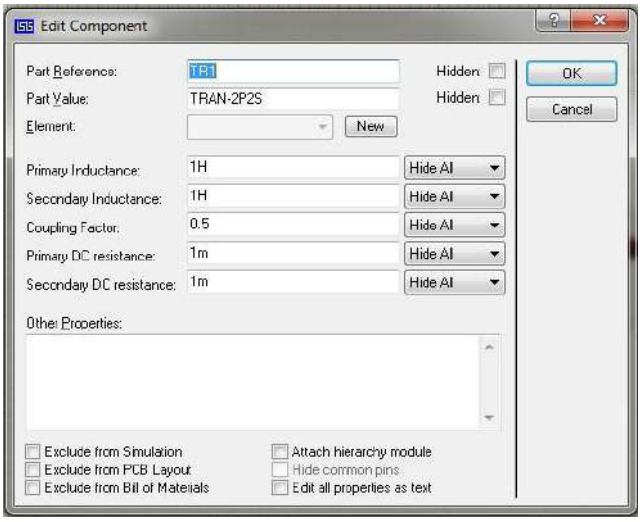

Fig. 14. Adjustment of the resistance of the respective windings of the transformer for 1m Ω.

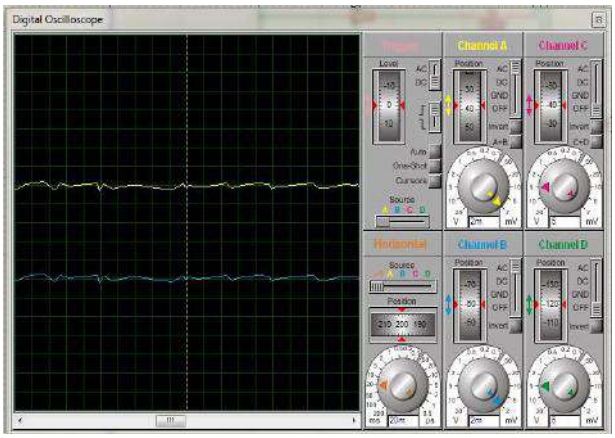

Fig. 14: Voltage curve at the level of the electroluminescent diode and the base of the transistor for a resistance of 1m Ω.

3.2. Achievements

3.2.1. Montage and interpretation

The realization of the combined circuit with its prototype is made from a resistance of value 1k , of power 1/4W, of a reference NPN type bipolar transistor 2N2222, an electroluminescent diode with a nominal voltage of 3.5V and a coil with a ferrite core.

Fig. 15 : Photo of the components necessary for the study of the circuit.

The coil is designed from a ferrite core of section 66mm2 (11mm height*6mm width). For its windings, we used five (5) identical wires of the same length l= 83cm and the same diameter d=0.6mm but of a different color to distinguish their placement. For the primary winding, we combined 3 wires of white, yellow and orange colors, the length being equal to l1=166cm for the equivalent of the number of turns N1=34. On the other hand, for the secondary winding, we combined 2 wires of black and blue colors, the length being equal to l2=249cm and the number of turns, to N2=58.

Fig. 16. Photo of the device powered by a BEXEL brand AAA battery.

When we directly fed the electroluminescent diode with any battery of nominal voltage 1.5V, it did not arrive to emit light because the output voltage was lower than the input voltage. Here, the simulation is verified.

When we then introduced the device into the circuit, the electroluminescent diode reacted to the effect of a battery of size AAA, nominal voltage 1.5V (see Fig. 19). This is explained by the presence of the coil and cell of the transistor because the power required was largely exceeded. The simulation predicted a voltage of 2.20V, but during the experiment, we got the value of 2.10V.

The circuit uses the self-oscillating properties of the oscillator block to form a converter tension (elevator). Like all power conversion technologies and in accordance with the law of energy conservation, none energy is created by the circuit. In fact, there tension de sortie est relevée en contrepartie d'une consumption de current increased at the entrance.

3.2.2. Efficiency test

To study its effectiveness, we tested the circuit with batteries of different shapes, or with different nominal voltages.

Tableau 8 shows the study of the efficiency of the circuit in presence of the device through some varieties of batteries used.

Fig. 17. Test d'évaluation of a pile of dimension D of brand ENERGY.

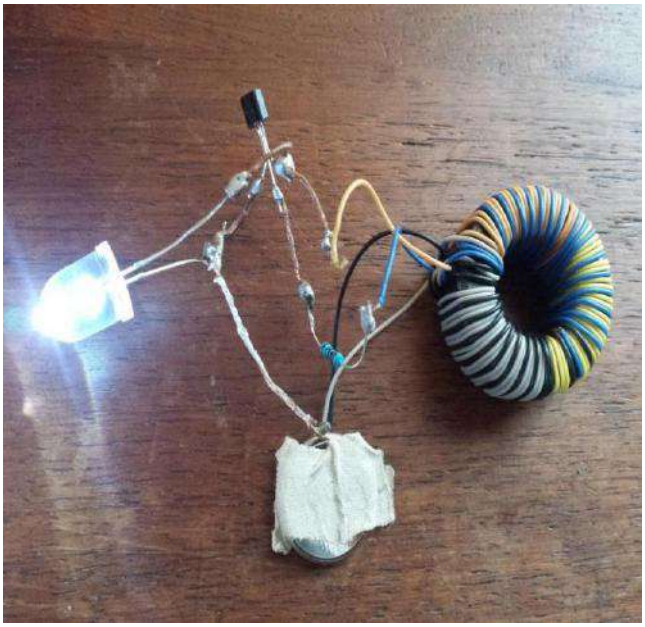

Fig. 18. Evaluation test of a CR2032 button cell.

Fig. 26: Evaluation test of a pile of size N (see table 4) , brand ALKALINE.

Table 8: Study of battery efficiency with the device.

Dimensions of the batteries		AAA	AA	D	CR2032	N
Mark		BEXEL	HUATAI	ENERGY	PARASONIC	ALKALINE
Nominal voltage (V)		1.5	1.5	1.5	3	9
Electromotive force (V)		1.64	1.65	1.65	3.36	9.05
Threshold voltage (V)		0.39	0.37	0.36	0.40	0.32
Voltage drop (V)	in 04 h	0.092	0.020	0.042	0.126	0.018
	in 08 h	0.198	0.041	0.083	0.251	0.039
	in 12 h	0.303	0.059	0.124	0.359	0.058

	at 4 p.m	0.395	0.089	0.166	0.485	0.086
	in 20 h	0.499	0.105	0.208	0.605	0.102
	in 24 hours	0.592	0.121	0.249	0.736	0.116
Debit average (v/h)		0.026	0.006	0.011	0.031	0.005
Calculation of error		0.01	0.002	0.007	0.5	0.8
Autonomy (days)		3	11	7	5	-

The Fig. 27 presents the battery voltage drop curve as a function of time, at intervals of 4 hours during a day.

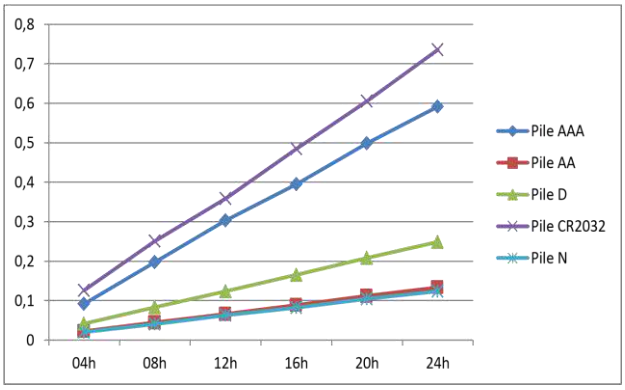

Fig. 27. Representative curve of the tension drops of each pile tested.

3.2.3. Longevity study

Afterwards, we studied the circuit in presence of the device but the batteries used are all identical (of the same nominal voltage, of the same size AA and of the same brand HUATAI). We measured the electromotive force of a pile and found that the electroluminescent diode reacted normally.

Fig. 28: Measurement of the electromotive force of a new AA battery.

Fig. 29. Installation of a single new battery of size AA with the circuit.

Fig. 30. Measurement of the electromotive force of three new batteries combined of size AA.

To see the longevity of the circuit, we have developed another branch so that three new batteries identical to the previous one (of the same brand HUATAI, of the same size

AA) are combined. Ainsi, their total electromotive force is added to give 4.93V.

For the electroluminescent diode to directly emit white light, the circuit logically needs an input voltage higher than or equal to its output voltage. The voltage of the direct branch requires a value of 2.10V while the circuit in the presence of the device requires a cell of 0.37V at least.

By directly feeding the electroluminescent diode with the three (3) combined batteries, we have seen that the electroluminescent diode shines without interruption for 12 days. However, the presence of the device strongly influences the energy consumption of the circuit. L'utilisation sans interruption d'une seule pile avec le prototype atteint presque l'equivalent d'un branchement direct avec ces trois piles. In fact, it only shifted by a day. Ainsi, the insertion of the prototype is very effective because it reduces the efficiency of the batteries needed for the lighting of the electroluminescent diode by almost a third.

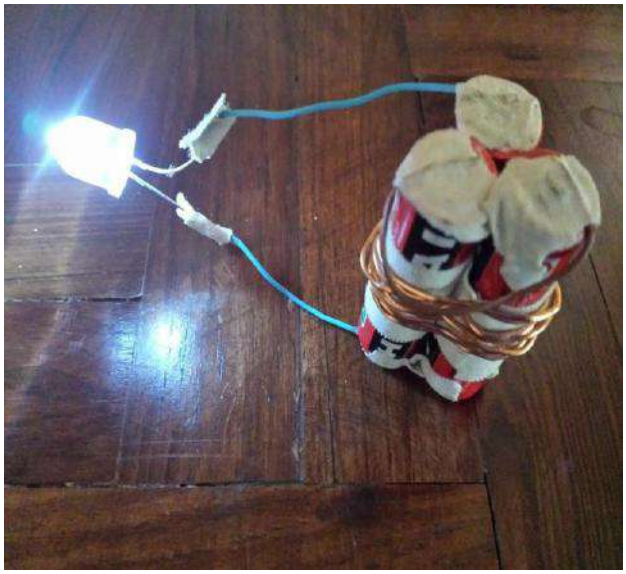

Fig. 31. Direct power supply of an LED by three new batteries of size AA.

Tableau 9 shows the results of comparing the circuit without the device and then with its presence.

Table 9: Longevity comparison between the direct branching and the presence of the circuit.

Montage			With device	Without device
Time / Autonomy (h)			Voltage (V)	
1 era day	Morning	12 o'clock	0.113	0.059
	Evening	24h	0.225	0.121
2nd day	Morning	36h	0.339	0.177
	Evening	48 hours	0.441	0.244
3rd day	Morning	60 hrs	0.554	0.296
	Evening	72h	0.665	0.351
4th day	Morning	84h	0.776	0.410
	Evening	96 h	0.890	0.468
5th day	Morning	108h	0.992	0.526
	Evening	120 hrs	1.103	0.547
6th day	Morning	132 h	1,215	0.658
	Evening	144 h	1,327	0.703
7 th day	Morning	156 h	1,438	0.761
	Evening	168 h	1,540	0.817
8th day	Morning	180 hours	1,651	0.884

	Evening	192 h	1,763	0.924
9th day	Morning	204 h	1,875	0.995
	Evening	216 h	1,988	1,065
10 th day	Morning	228 h	2,092	1,126
	Evening	240 hours	2.204	1,187
11 th day	Morning	252 h	2,317	1,249
	Evening	264h	2,428	1,311
12 th day	Morning	276 h	2,539	-
	Evening	288 h	2,640	-

IV. DISCUSSION

The realized circuit presents several advantages. First of all, it's easy to do. Then, its use allows you to save a lot more electricity. It is very practical for special lighting, at home because it happens to feed an electroluminescent diode for more than a week, without interruption for good quality batteries. In addition, the device can be integrated into various electronic devices.

Its use also favors the protection of the environment because once the used batteries are flat, they are no longer immediately thrown away because they can now be revalued by this device. As a consequence, the uncontrolled waste of batteries is now likely to decrease and the pollution of our environment is thus reduced and the risks threatening the health of living beings are less harmful.

The use of the prototype also allows you to save money because the acquisition of the raw materials used is often cheaper than the purchase of finished products, this is valid, at the same time, for the purchase of batteries but also for The purchase of electronic components and their assembly.

This circuit is marketable and especially profitable considering the criteria of energy saving.

Disadvantages

Despite its advantages, the device also has some disadvantages. The fabrication of the prototype requires more time because the components must be controlled un par un and all must be soldered before assembly.

Sometimes, these components are imported by retail boutiques.

The injection of this prototype also requires additional space in an electronic device.

V. CONCLUSION

To conclude this work, we can say that the prototype designed gives satisfactory results because its efficiency far surpasses our expectations.

The simultaneous presence of the coil and the transistor are essential for the realization of the circuit because one allows increasing the input voltage, while the other increases the current intensity. The prototype can be adapted to all types of new or used batteries. It also has a great longevity and its use allows well to extract the remaining charges from a used battery provided that the input voltage remains above 0.37V for the prototype made.

In a developing country like Madagascar, the conventional price of energy continues to increase while the purchasing power of the population decreases. Non-renewable energies are more or less accessible depending on the income of each household. But, they are becoming more and more coveted and recommended throughout the world.

In anticipation of the implementation of measures conforming to the disposal of used batteries, it is preferable to insert this type of prototype in various electronic devices because it allows energy and money to be saved. Above all, its utilization favors the protection of the environment because the revaluation of these used batteries reduces their uncontrolled discharge and the diminution of toxic waste harmful to human health.

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Contribution of GIS and participatory Mapping for the analysis of the cropping system in the circle of Kita, in Mali

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Abstract— *The development of geospatial technologies allows the creation of numerous services in all areas. In agriculture, their use is much more oriented towards mapping and evaluating agricultural areas. However, the identification and mapping of crops through GIS tools remains a major challenge especially in its African context. The objective of this work is to analyze the crop systems of the terroirs of Banfara, Madina Malinké and in the circle of Kita using GIS tools. To achieve this objective, we used the Google Earth Pro database for the years 2020 and 2021. Through a participatory approach, all the plots and the type of cultivation practiced were identified and mapped. After digitizing the agricultural plots, we carried out field observation in order to validate them. Geoprocessing operations and descriptive analyzes were then carried out. The methodological approach adopted allowed the exhaustive mapping of agricultural plots in the areas of Banfara, Madina Malinké and Toufinko. During the two agricultural seasons 2019-2020 and 2020-2021, the results show a dominance of cereal crops in the village of Banfara and a dominance of cash crops in the villages of Madina Malinké and Toufinko.*

I. INTRODUCTION

The diversity of crops in the landscape contributes to the reduction of weeds on the plots while allowing the improvement of yields (Ouyang et al., 2020). Additionally, a landscape with diverse plant species reflects nutritional diversity and food security (Kpienbaareh et al., 2020). Thus, mapping agricultural landscapes for the identification of crop types, assessing their spatial distribution and cropping systems is essential to guide decision-making in agricultural planning and environmental management (Kpienbaareh et al., 2021). However, mapping crop types in smallholder farming systems in sub-Saharan Africa remains a challenge due to the cost of data, homogeneous landscape characteristics, climatic conditions limiting the clarity of images during much of the year.

In fact, satellite images available to the general public are limited for these types of operations. According to (Bellon De La Cruz, 2018) in West African countries, the only possibility offered by these satellite images is the evaluation of the area of agricultural masks. Moreover, satellite images acquired in Africa are most often difficult to use due to

cloud cover at the time of acquisition of these images (Chen et al., 2018; Pittman et al., 2010; Wei et al., 2020).

The Google Earth software has a freely accessible image database (in RGB color) which is regularly updated. In recent years, many researchers have used data from this software as part of their studies (Baro et al., 2014; San Emeterio & Mering, 2021). Although these authors used the background of Google Earth software for different studies such as urban planning, it also offers great exploitable potential in agriculture.

Participatory mapping is an old practice allowing a finer representation of a territory with local stakeholders. Indeed, this participatory mapping method is generally limited to the representation of urban practices or the simple location of geographical entities on a map, from the mapping of territorial changes to the distribution of socio-community infrastructures (Cormier - Salem et al., 2017; Lefebvre et al., 2017; Choplin & Lozivit, 2019). In agriculture, it is essential to co-construct the agricultural land in the presence of local producers in order to highlight the choice of crops on the plots and their sequences over different agricultural seasons (Traoré & Le Bars, 2018).

In this article, we adopted a combined approach of participatory mapping with geospatial technologies to map the sequence of crops in the circle of Kita in Mali in order to obtain an accurate representation of the agricultural landscape of the terroirs concerned.

II. METHODOLOGY

2.1 Geographical framework

This work was carried out in three areas (Banfara, Madina Malinké and Toufinko) located in western Mali, in the Kita circle (**Fig.*1***). Agriculture is the main activity of the inhabitants of these three regions.

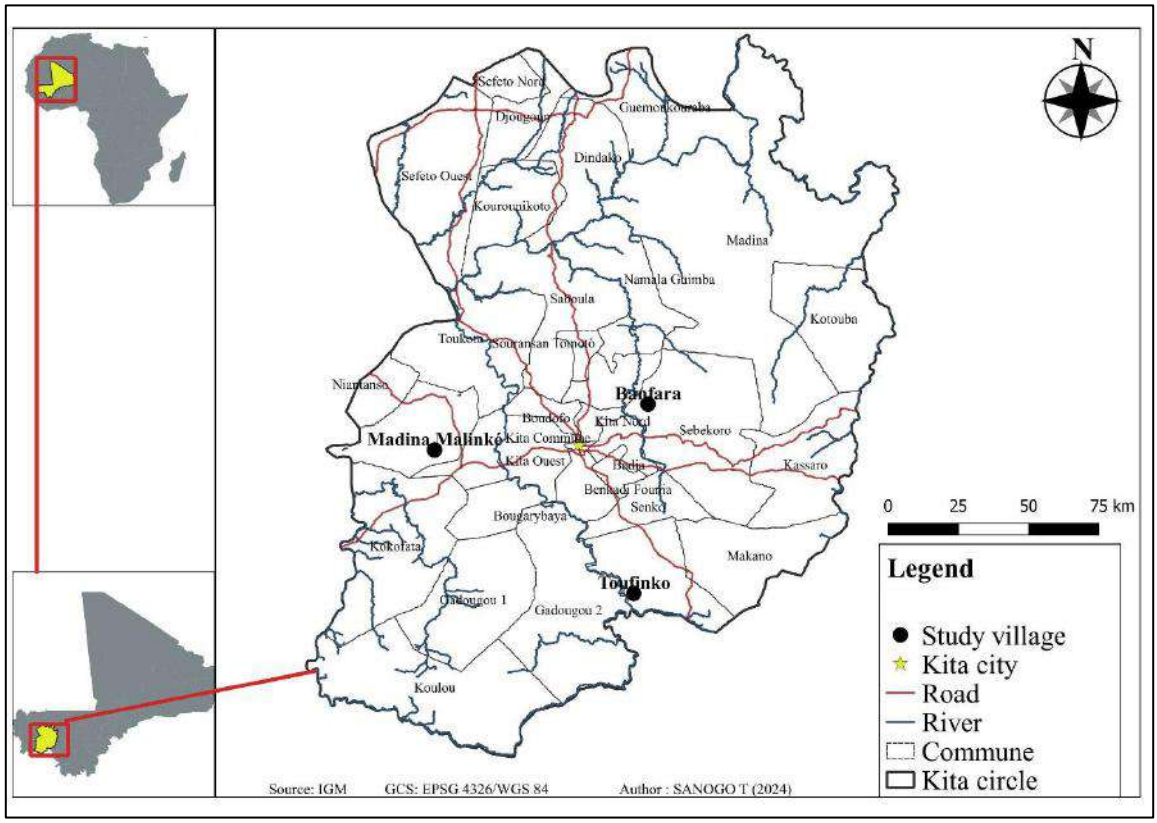

Fig.1: Location of study sites

The Banfara village land is a locality attached to the rural commune of Sebekoro to the east of the urban commune of Kita. It is between the geographical coordinates 9°14'0" and 9°18'0" of western longitudes and 13°9'20" and 13°11'10" of northern latitudes with an area of 29 Sq.km. Madina Malinké is a village located in the commune of Kobri in the West and 45 km from the town of Kita. Its geographical area is located between longitudes 9°56'0"W and 9°58'0"W and latitudes 13°0'00'N and 13°03'0"N with an area of 22 Sq.km.

The village lands of Banfara and Madina Malinké all have similar physical characteristics. They are located in the Sudanian climatic zone with an average annual rainfall

which varies between 600mm and 1200mm of rain per year. The temperature varies between 25°C and 33°C. The relief is relatively flat, leaving room for very large shallows. The type of soil most encountered in the terroirs is loamy. The vegetation is made up of a carpet of shrub savannah which dominates but also a carpet of tree savannah located in the southern part of the Banfara region. In the Madina Malinké land, the shrub savannah also constitutes the large plant cover, but we also observe a gallery forest which spreads out along the watercourse.

The Banfara region has a population of 786 inhabitants. According to the general census of the population of the habitat, the region of Madina Malinké was home to 852 inhabitants (INSTAT-MALI, 2009).

The Toufinko region is a hamlet of Sirakoro (the capital of the rural commune of Sirakoro) on the Bakoye River. It is located south of the town of Kita over a distance of 70km. With an area of 27 Sq.km, it is between longitudes 9°17'30"W and 9°20'0"W and latitudes 12°30'00"N and 12°34'0"N. The average annual rainfall varies between 700mm and 1300mm of rain per year (IER, 1976). Its population is 378 inhabitants (PDSEC, 2021).

2.2 Materials

The equipment used for this research is essentially geomatics software, including Google Earth and Qgis for geoprocessing and data analysis. Then, a questionnaire (guide) was developed and sent to farm managers to identify the types of crops on the plots delimited by agricultural campaign.

2.3 Methods

Data collection was done in two phases simultaneously. First, the Google Earth image is projected on a screen which allows the identification of the different space objects. Then, using landmarks or orientation points (roads, rivers, mosques, etc.) visible in the image, each farm manager follows the path that leads to his or her field. After identifying the cultivated area, discussions were held to delimit the different plots. This delimitation is assisted by other producers to avoid any confusion. The boundaries of the plots are thus materialized in the Google Earth software. Secondly, the sequence of crops practiced on each identified plot is then administered in a questionnaire using the administration of the questionnaire incorporated in a tablet. The main informations on the plots are: the identification number of the plot which is similar to the identification code on Google Earth, the first and last name of the farm manager, the type of crops on the plot during 2019-2020 the agricultural campaign and that of 2020-2021.

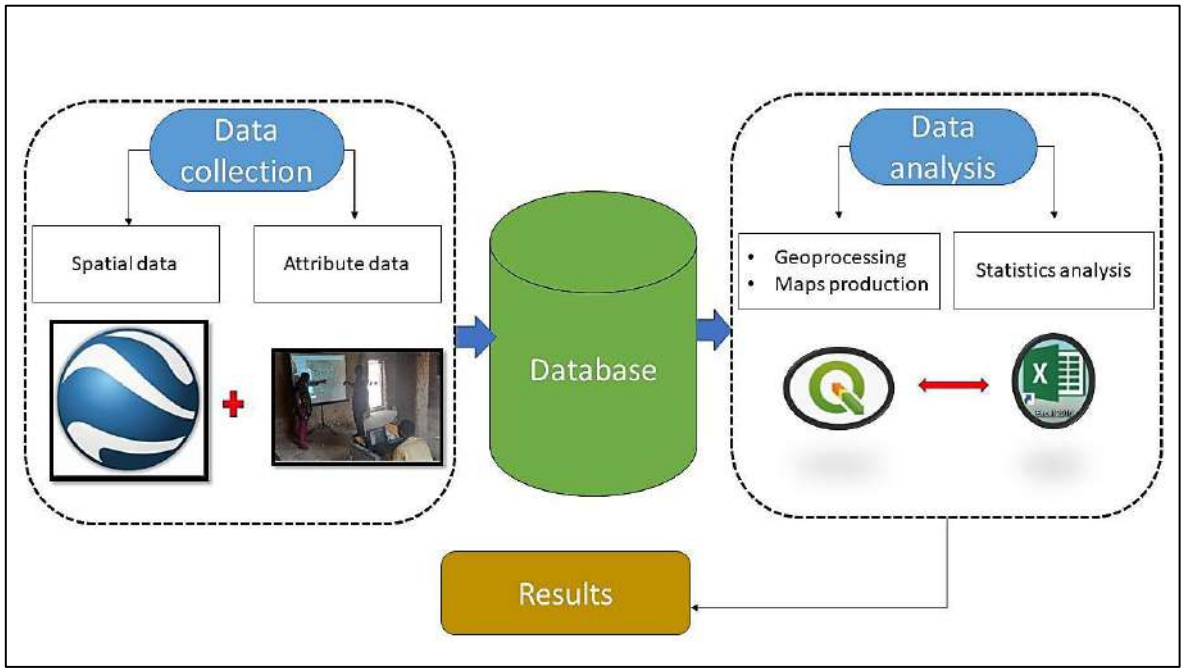

Fig.2 : Methodological diagram of culture mapping

We carried out geoprocessing of the digitized data on Google Earth (GE) and the questionnaires. This phase essentially consisted of making it easier to manipulate the data digitized on Google Earth in Keybole Markup Language (KML) format and creating a link between the tabular data (plot identification code, first name and last name of the head of farm, type of crops) and geographical data. To do this, the digitized polygons (plots) were

converted from KML format to "Shapefile" format. To link geographic and tabular data, the attribute table management operation (attribute join) was carried out in QGIS under the ***" join " function.*** Despite the high precision of the images from the Google Earth software and the great ability of farm managers to read the image, the cartography was validated by comparing the results obtained with the realities on the ground. To do this, in each terroir, ten (10) plots were selected by reasoned choice in order to carry out validation. The centroid points of these parcels were then created and integrated into a mobile GIS application (QField). A close correspondence between the mapped plots and the realities on the ground was therefore noted. Additional analyzes using the descriptive statistics method were carried out to obtain statistical information. This is the area per type of crop in hectare and percentage.

III. RESULTS

3.1 Mapping of Banfara crop rotations during the 2019-2020 and 2020-2021 agricultural seasons

During the 2019-2020 agricultural campaign, the crop rotation map shows an uneven distribution of species cultivated on the different plots (**Fig.*3***).

The results show a high concentration of crops in the center of the terroir. They indicate that the plots cultivated with cotton during the 2019-2020 agricultural campaign are highly concentrated in the South-East of the region. Food crop plots (corn, millet, sorghum and rice) are mainly located in the center. The peanut plots are distributed on both sides. The size of the plots varies greatly. Despite an aggregation of food crops (corn, millet, sorghum and rice), cotton soles have a very large influence on cultivated areas.

Cotton plots represent 34% of the total cultivated area, cereal crops 30%, peanut plots constitute 20%, sesame, market gardening and fallow represent respectively 7%, 4% and 5%.

During the 2020-2021 agricultural season, the distribution of crops underwent changes (**Fig.*4***). The cultivated area in the South of the region is mainly characterized by the dominance of cotton plots but they are also much more representative in the North-West than all other speculations. As for the plots of food crops, peanuts and sesame, they are scattered throughout the land. The plots of market gardening are located all around the home site.

During this agricultural campaign, the results show that the area allocated to cotton cultivation increased. While it occupied 34% of the total crop area during the 2019-2020 agricultural season, the cotton area amounts to 42%.

This increase in the area of cotton cultivation came at the expense of food crops which increased from 30% during the previous campaign to 25% during the 2020-2021 agricultural campaign. Peanut plots represent 19%, sesame cultivation, market garden products and fallow land make up a total of 14%.

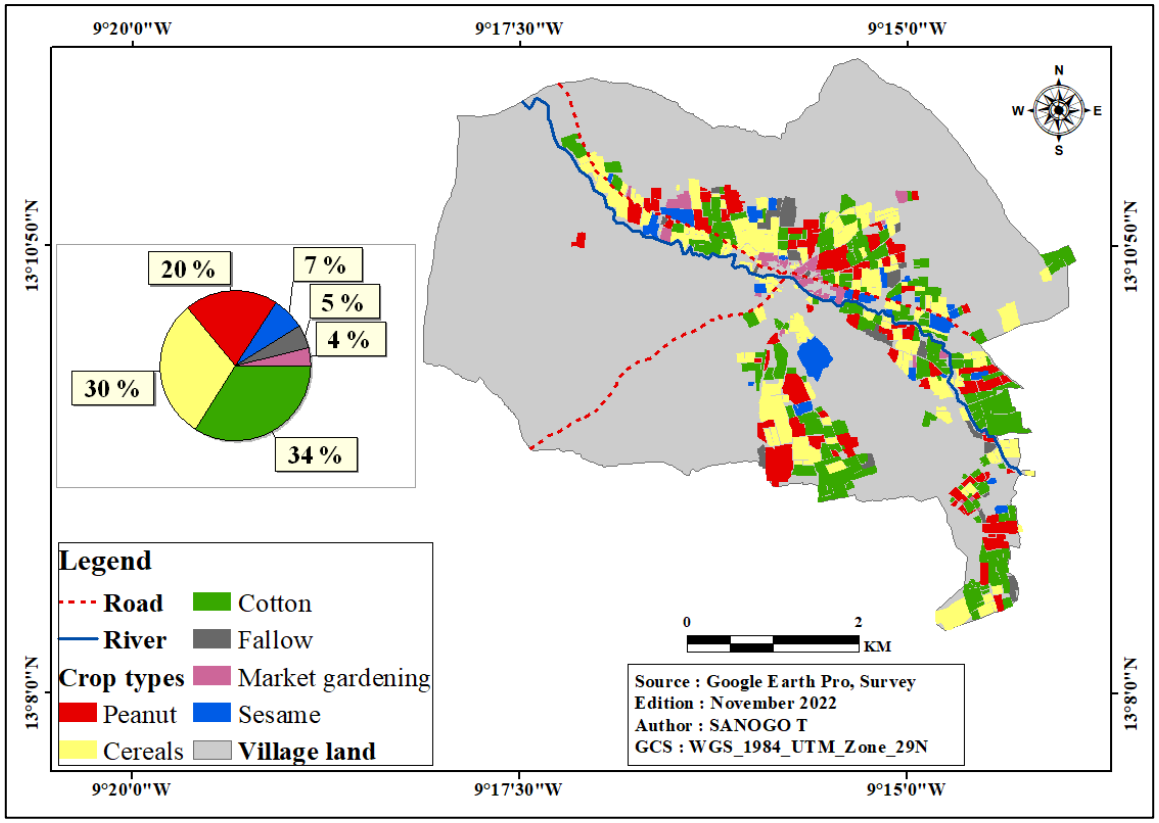

Fig.3: Distribution of Banfara crops during the 2019-2020 agricultural season

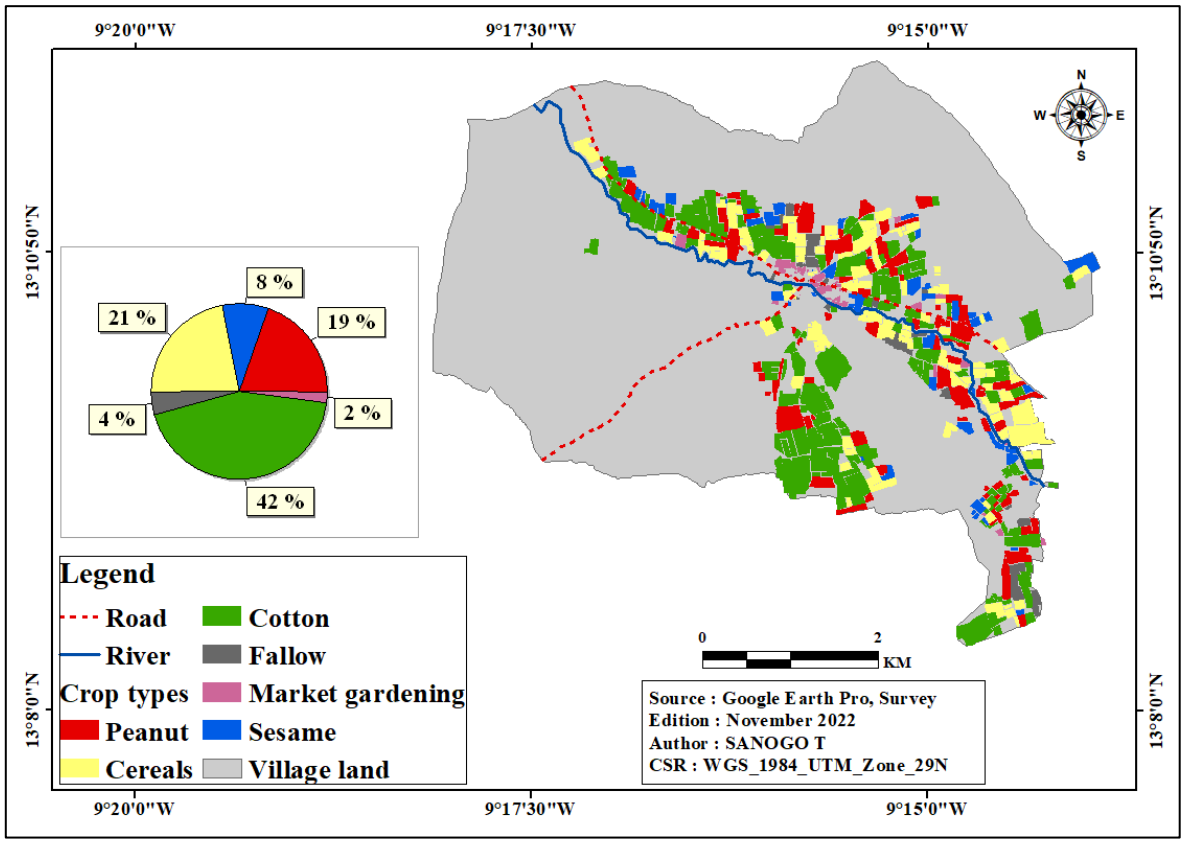

Fig.4: Distribution of Banfara crops during the 2020-2021 agricultural season

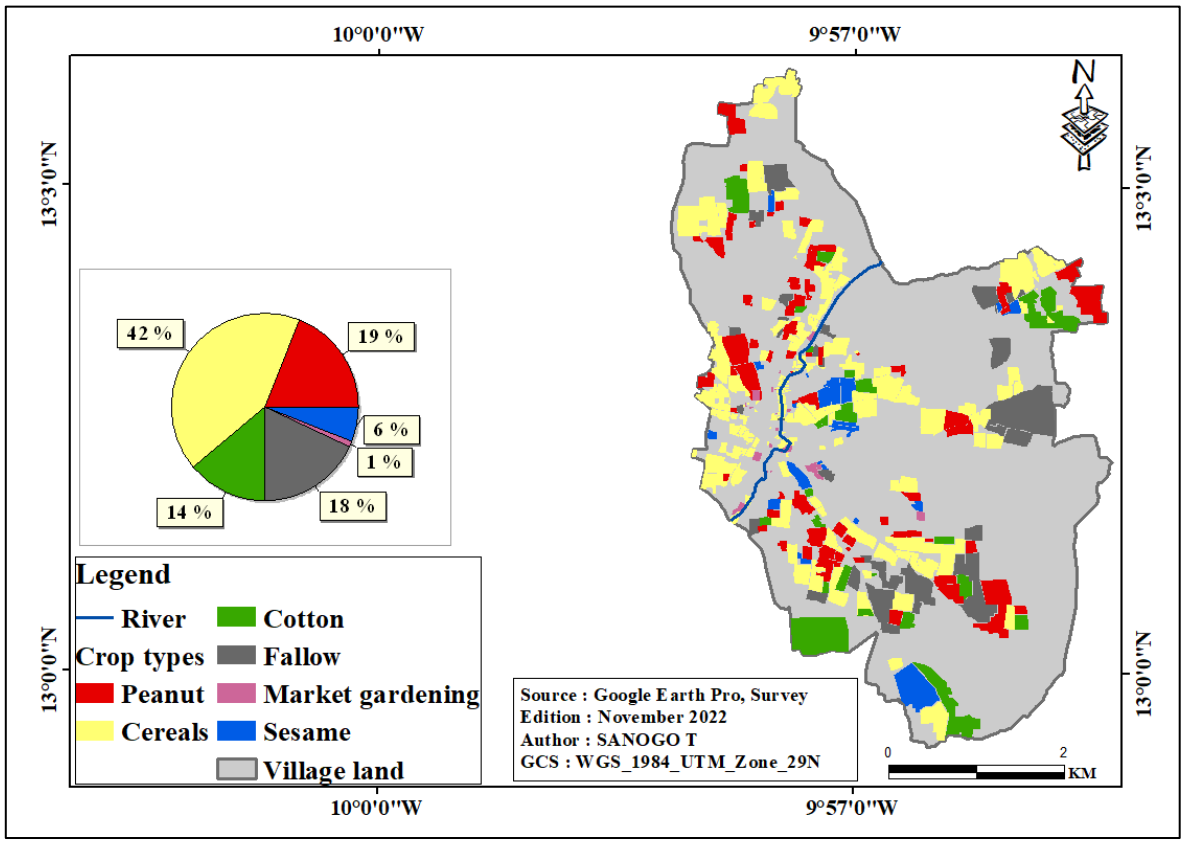

Fig.5: Distribution of Madina Malinké crops during the 2019-2020 agricultural season

3.1 Mapping of Madina Malinké crop rotations during the 2019-2020 and 2020-2021 agricultural seasons

The distribution of crops in the Madina region is marked by a strong dominance of food crop plots (**Fig.*5***).

In the North and West, the cereal and peanut plots are the most representative, in the South, we observe emulation between the cereal, peanut and cotton plots but also some fallow plots. In the South, cereal plots dominate with the presence of a few cotton and peanut plots and fallow plots.

In Madina Malinké during the 2019-2020 agricultural campaign, cereal crops occupied 42% of the total cultivated area, peanuts represented the second dominant crop with 19%, fallow and cotton had 18% and 14% respectively. Plots with sesame and vegetable crops were the lowest represented with 4% and 1%.

In the North and West, the cereal and peanut plots are the most representative, in the South, we observe emulation between the cereal, peanut and cotton plots but also some fallow plots.

In the South, cereal plots dominate with the presence of a few cotton and peanut plots and fallow plots.

In Madina Malinké during the 2019-2020 agricultural campaign, cereal crops occupied 42% of the total cultivated area, peanuts represented the second dominant crop with 19%, fallow and cotton had 18% and 14% respectively. Plots with sesame and vegetable crops were the lowest represented with 4% and 1%.

During the 2020-2021 agricultural campaign, the distribution of crops is characterized by a different trend from the past campaign (**Fig.*6***). In the North, peanut cultivation dominates and fallow plots, cotton cultivation are highly concentrated in the South with a few cereal and peanut plots.

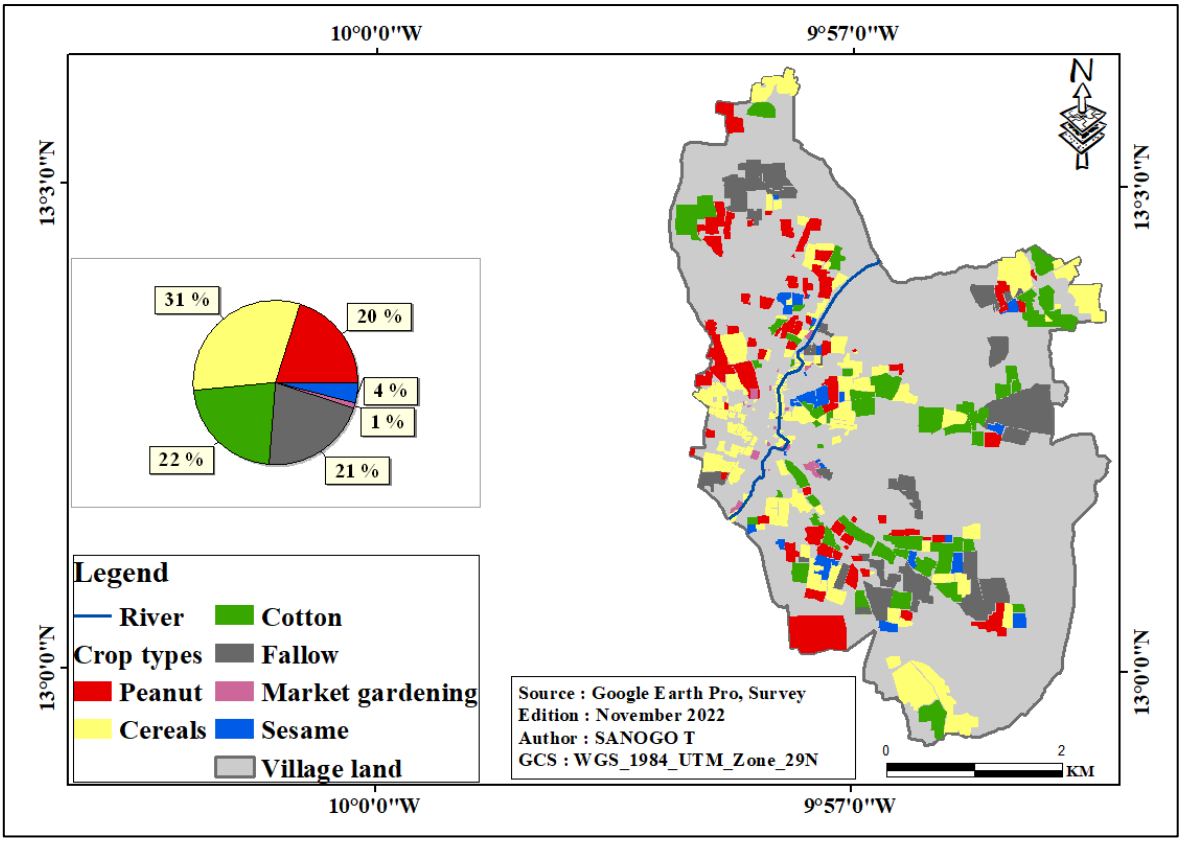

Fig.6: Distribution of crops in Madina Malinké during the 2020-2021 agricultural season

Also in the East, we observe a strong presence of cotton plots and certain cereal plots. On the other hand, in the west of the region, there is a strong dominance of plots of food crops and a few plots of peanuts.

During this campaign, the area of cereal crops fell significantly in favor of cotton cultivation. During the 2019-2020 agricultural campaign, the cereal area was 42% compared to 31% during the 2020-2021 agricultural campaign (**Fig.*6***). In the case of cotton, the allocated area constituted 14% against 22%. As for peanut and sesame crops, they did not experience a big change with 20% and 5% respectively. On the other hand, there are more plots left fallow (i.e. 21%).

3.2 Mapping of Toufinko crop rotations during the 2019-2020 and 2020-2021 agricultural seasons

In the Toufinko region, the cropping system is characterized by a dominance of sesame and cereal cultivation. Following the soil conditions which offer very limited potential for agricultural practices, crops are mainly located in the river bottom. During the 2019-2020 agricultural campaign, in the center of the land (the village site) we observed a dominance of plots growing cereals (**Fig.*7***). In the South, cereal plots are mainly presented with sesame and some cotton plots. In the West, peanut plots are the most representative with sesame and cereals.

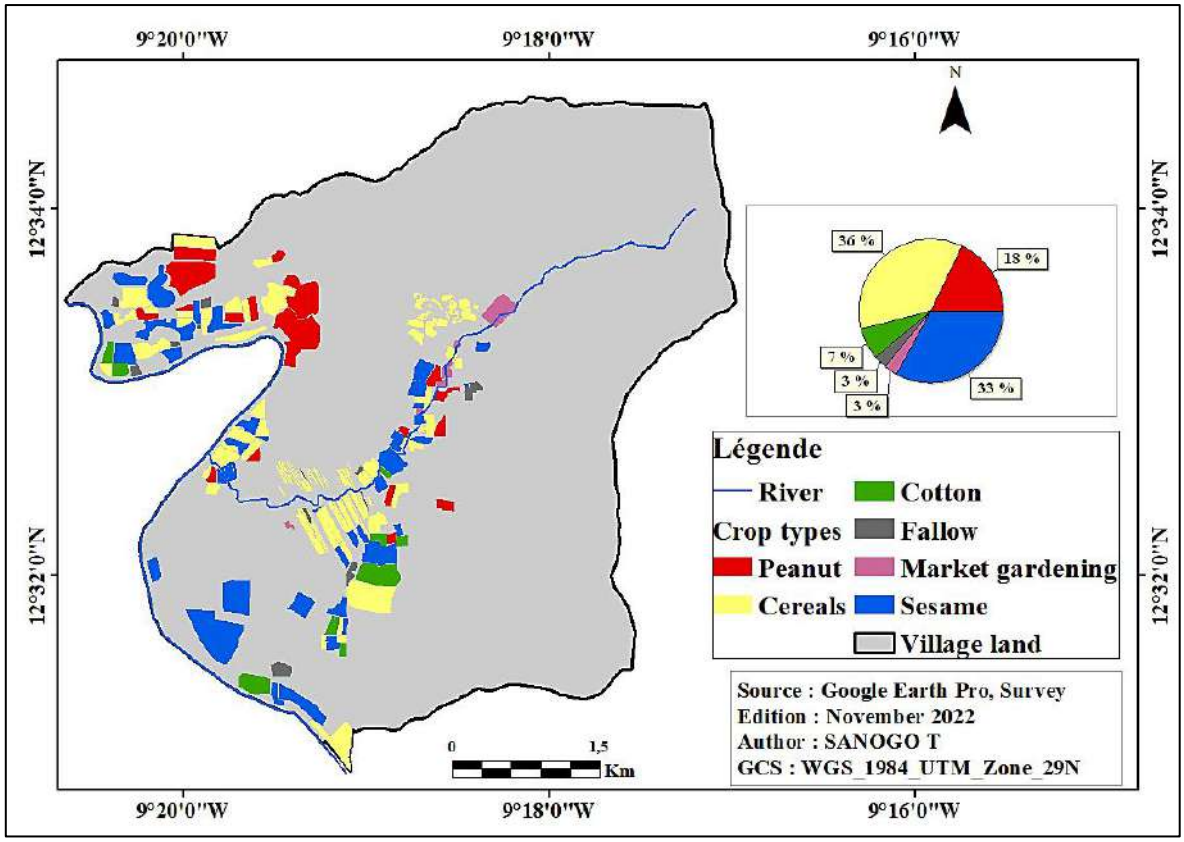

Fig.7: Distribution of Toufinko crops during the 2019-2020 agricultural season

In Toufinko, cereals and sesame are the most dominant with the largest areas during the 2019-2020 agricultural campaign with respectively 36% and 33% of cultivated areas. Peanuts comprise 8%, cotton 7% and vegetable crops constitute 3%.

The spatial distribution trend of crop types during the 2020-2021 agricultural campaign remains similar to the previous agricultural campaign (**Fig.*8***). Around the houses in the center of the land, it remains exploited for the cultivation of cereals, in the South the sesame and cereal plots are located and the same reality is observed in the West.

Likewise, statistically, the areas per type of crop have experienced small changes. The areas intended for cereals are 38% of cultivated land, sesame cultivation represents 31%, peanut plots occupy 14%, cotton cultivation constitutes 10% and 4% of cultivated land is fallowed.

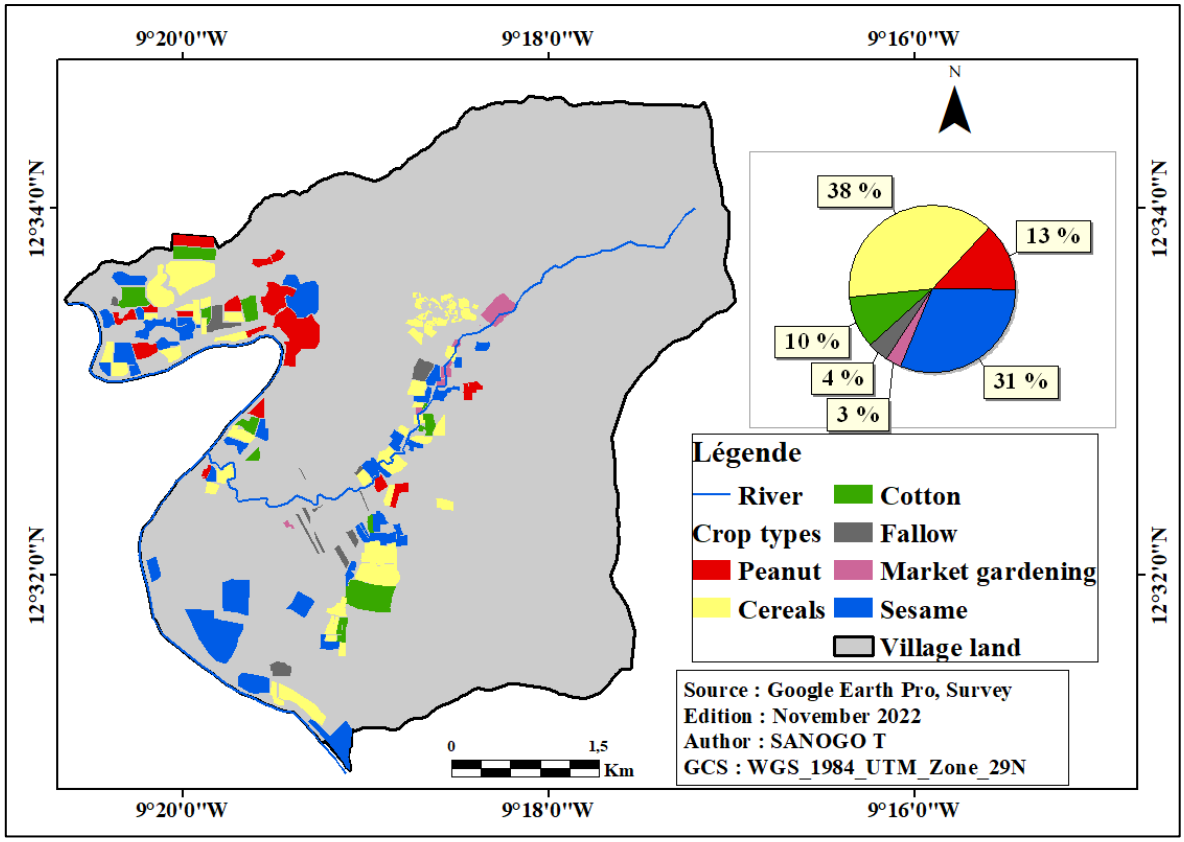

Fig.8: Distribution of Toufinko crops during the 2020-2021 agricultural season

IV. DISCUSSIONS

The acquisition of agricultural information on what is produced (types of crops) in time and space constitutes a major asset for carrying out this research. Indeed, having such information is a springboard for agricultural monitoring, particularly in the context of food security. Thus, maps of crop types over two agricultural seasons in the terroirs of Banfara, Madina Malinké and Toufinko were established with very great precision. This constitutes one of the great strengths of this work. However, the mapping of crop types in agricultural landscapes in Africa is mainly limited by its heterogeneous composition, lack of temporal data and cloud cover (Kpienbaareh et al., 2021). Furthermore, the accuracy of classification of crop types through classification algorithms rarely exceeds 80% correspondence of trained results to field data (You et al., 2021).

The maps produced made it possible to understand the cropping systems practiced in these areas based on the crop rotation maps for the 2019-2020 and 2020-2021 agricultural seasons. The results show that the Banfara cultivation system is characterized by a dominance of cotton and peanut cultivation (**Fig.*4***). Previous studies confirm that the Sudano-Guinean zone of Mali is characterized by an agricultural system dominated by cotton, which constitutes the primary cash crop in the zone (Vintrou, 2012). In Madina Malinké the cultivation system is mainly composed of cereals followed by peanuts and cotton (**Fig.*6***). These results corroborate with those of Kpienbaareh et al., 2020 in Malawi where crop distribution is mainly dominated by maize. However, in Toufinko, it is mainly dominated by sesame cultivation (**Fig.*8***). Which means that the cropping systems of these three areas are strongly dominated by cash crops (cotton, peanuts and sesame) except in Madina Malinké (sorghum, millet and peanuts). Furthermore, according to Dembele, 2018 the cultivation systems in the cotton zone in Mali are characterized by a very great diversity of crops which allows a distribution of economic and environmental risks. The research results of Konduri et al., 2020 show a possibility of crop mapping with more or less acceptable precision. These authors assert that cereal crops largely constitute the US cropping system.

The participatory approach to crop mapping carried out using very high spatial resolution images constitutes a great asset of this research. This method above all made it possible to take into account the actual size of the plots but to avoid possible errors of confusion with the type of cultivation practiced on the plots. However, despite the

subtlety of reading Google Earth images, producers could be mistaken about the succession of crops on a plot during the different agricultural seasons.

V. CONCLUSION

This research presents the contribution of geospatial technologies to participatory mapping of crop rotation. The results show a great performance of this combined approach. The main crops in Banfara are cotton which exerts great pressure on other crops, followed by peanuts and sorghum. Banfara's cropping system is dominated by sorghum, peanuts and cotton in Madina, however, the main crop is sesame in Toufinko. Additional research is necessary to assess the agricultural production capacities of these localities.

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Impact of Ergonomics on Workers' Performance and Health

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***Keywords*— health, work performance, productivity, ergonomic engineering**

***Abstract*—** *Ergonomics emerges as an essential scientific discipline, driving health, safety and increased productivity in work environments. This study aims to examine, based on the contributions of renowned authors, the application of ergonomics in Brazilian workplaces, highlighting its impact on the health and productivity of employees. The methodology adopted is a literature review from various official sources. Research has shown the relevance of physical and cognitive ergonomics in preventing musculoskeletal disorders and promoting well-being at work. It was clear that with the improvement in workers' quality of life, fatigue and stress are avoided, which improves the relationship between employees and employers, increasing productivity. The study shows the importance of applied research to strengthen ergonomic practices in organizations. The future of ergonomics is intrinsically linked to its ability to adapt and respond to new challenges, maintaining the commitment to promoting work environments that prioritize and cultivate human well-being.*

I. INTRODUCTION

According to Ferreira, Merino and Figueiredo (2017), ergonomics is the science of work, which studies interventions between human beings and other elements of the system, applying theories, principles, data and methods to projects to optimize human well-being. and overall systems performance.

Since among the factors that make up the work environment, ergonomic factors are those that significantly interfere with job satisfaction, in addition to being responsible for several issues that emanate from the workplace and need to be studied, ergonomic awareness now has , in this context, according to Gungor (2009), a substantial impact on the industry, organization, management, employees and general well-being of the system.

Nowadays, Mental Health practices in organizations coexist with pressure for increasing productivity, in a very competitive environment, in which the individual must always be ready for changes and adapt to market demands (VASCONCELOS; FARIA, 2008).

According to Vasconcelos and Faria (2008), in addition to working conditions, research showed that pressures resulted from the organization of work (division of tasks, repetition, cadence, hierarchy, command, control). For Dejours (1992), working conditions target the body, while the organization of work affects psychic functioning.

Sarmento and Villarouco (2020) show that ergonomics has consolidated itself as a key area for improving working conditions, adjusting the environment to meet the needs of workers. This approach underlies the first dimension of this research, focused on physical ergonomics and its importance in preventing musculoskeletal disorders and promoting work efficiency.

Additionally, studies such as Soares (2009) highlight that the benefits of ergonomics transcend individual well-being, positively impacting the organization by reducing absenteeism and increasing employee motivation. This perspective reinforces the relevance of understanding ergonomic practices as a strategic element for organizational development, an aspect explored in this work.

Ergonomics, understood as the science that seeks to optimize the relationship between workers and their work environments, plays a fundamental role in promoting the health, well-being and operational efficiency of individuals. In Brazil, the implementation of ergonomic principles faces particular challenges that reflect the need for detailed investigations into their effectiveness and adaptation to the national reality.

The ergonomics of the built environment, according to Sarmento and Villarouco (2020), provides valuable insights into optimizing spaces for health and efficiency, highlighting the importance of design and spatial configuration in the effective implementation of ergonomic practices.

The engagement of workers in the creation of ergonomic solutions, as pointed out by Soares (2009), is crucial to the success of these measures, ensuring that they are not only technically adequate, but also aligned with the expectations and needs of employees, an aspect that will be rigorously examined in this study.

This study aims to examine, based on the contributions of renowned authors, the application of ergonomics in Brazilian workplaces, highlighting its impact on the health and productivity of employees, contributing significantly to the field of ergonomics, suggesting strategies that maximize its benefits for workers and organizations.

The research presents a qualitative approach, which Gil (2019) highlights as important for investigations of lived experiences and Marconi and Lakatos (2019, p. 303) address that “the qualitative study develops in a natural situation, offering a wealth of data descriptive, as well as focusing on reality in a complex and contextualized way”.

Therefore, the research was developed in accordance with the principles of qualitative bibliographical research, through the search for already prepared material that discusses teaching through investigation and scientific literacy. Books and scientific articles were collected from databases such as: Scielo, Google Scholar, online repositories of universities and scientific journals.

Qualitative research in ergonomics, discussed by Palazzo and Diez-Garcia (2021), is essential for understanding the experience of workers and evaluating the effectiveness of ergonomic interventions. This study is dedicated to critically analyzing such perspectives, aiming to map perceptions about ergonomic practices and their concrete impacts on well-being and productivity.

II. FUNDAMENTALS OF ERGONOMICS

Ergonomics transcends mere spatial organization, involving a detailed analysis of the interaction between people, equipment and the environment. As Sarmento and Villarouco (2020) point out, this discipline is crucial to promoting well-being in multiple dimensions, encompassing not only physical comfort, but also mental and emotional aspects of workers. This holistic view allows for a broad understanding that employee well-being is influenced by a variety of factors, in addition to the physical, underpinning the importance of a properly designed work environment.

Furthermore, ergonomics continually adapts to new technologies and social transformations, highlighting the need for adaptability to meet the contemporary demands of work environments. Sarmento and Villarouco (2020) highlight that ergonomics must be a dynamic discipline, capable of responding promptly to the demands of today's workplaces, showing that ergonomics is a science in constant evolution, committed to offering relevant and effective solutions to the challenges of workers.

The interaction between different areas of knowledge, defended by Connor et al. (2023) and Jun et al. (2021), constitutes one of the foundations of ergonomic practices, highlighting the importance of multidisciplinary collaboration in creating healthy and efficient work environments. The fusion of different specializations contributes to the emergence of more complete and effective solutions, significantly improving well-being in the work environment.

Incorporating the contributions of Lima and Duarte (2014), it is understood that ergonomics, when acting from the initial design and engineering phases, can

significantly influence the final project solutions. By providing abstract "usage settings" that capture the essence of human interactions, ergonomists can guide design decisions in a more informed manner, ensuring that ergonomic aspects are integrated effectively from the beginning of the design process.

Furthermore, placing the human being at the epicenter of ergonomic considerations, as highlighted by Sarmento and Villarouco (2020), is essential to align employee well-being with the company's strategies. Person-centeredness in ergonomic practices ensures that actions are not only technically correct, but also strategically aligned with the organization's purposes and aspirations.

The implementation of ergonomic practices, highlighted by Connor et al. (2023) and Jun et al. (2021), demonstrates the company's commitment to the health and comfort of workers, establishing ergonomics as a competitive differentiator. This investment in human capital is recognized as an action that adds value not only to individuals, but also to the organization as a whole.

The ability of ergonomics to renew itself in the face of changes in the job market, as emphasized by Sarmento and Villarouco (2020), is also necessary to keep work practices aligned with innovations and best practices in the field. This dynamism ensures that ergonomics remain

relevant and effective, adapting to meet new technological and organizational demands.

Finally, the integration of ergonomic practices into corporate strategies, as emphasized by Connor et al. (2023) and Jun et al. (2021), highlights ergonomics as a preventive strategy that benefits all stakeholders. By adopting ergonomic principles, organizations not only respond to current challenges, but also prepare for a brighter future by cultivating a work environment that promotes innovation, health and sustainability.

III. ERGONOMICS AND ITS DOMAINS

The term Ergonomics is derived from two Greek words, ergon, which means work, and nomos, which translates as natural laws, which together define the science of work and a person's relationship with that work. According to the International Ergonomics Association, Ergonomics is technically defined as: the scientific discipline concerned with understanding the interactions between humans and other elements of a system, and the professional field that applies theory, principles, data and methods to design , in order to optimize human well-being and overall system performance (NAEINI; MOSADDAD, 2013).

According to Dul and Weerdmeester (2012), Ergonomics can be understood, more broadly, as the study of the design of a workplace, equipment, machine, tool, product, environment and/or system that considers physical, physiological capabilities , biomechanics and also psychological aspects of the human being.

Ergonomics science has three domains: physical, cognitive and organizational, the latter being a type of macroergonomics, through the understanding of organizational culture, work projects, human resource management, quality management and network and communication organization. According to Martins and Ferreira (2015, p.128), the three domains are:

> **physicist**— related to those that characterize the physical activities of the human body, such as anthropometric, biomechanical, anatomical and physiological aspects, thus studying posture at work, material handling, repetitive movements, work-related musculoskeletal disorders; cognitive — are focused on mental processes, involving perception, memory, information processing, reasoning and motor response, having mental workload, decision making, specialized performance, human-computer interaction, stress; organizational — related to the optimization of socio-technical systems, organizational structure, policy and process, such as communications, work design, temporal organization of work, new work paradigms, organizational culture, quality management.

3.1 Physical Ergonomics and Musculoskeletal Disorders

Musculoskeletal Disorders (MSDs) have a profound impact on the health and efficiency of workers, and it is essential to address them from an ergonomics perspective. Ramos et al. (2022) highlight the relevance of understanding and mitigating these conditions in the workplace, emphasizing that a detailed analysis can reduce the incidence of MSDs. Physical ergonomics is dedicated to adjusting the work environment to minimize these disturbances, providing effective solutions to improve employee health. Adaptations may include redesigning workstations, introducing ergonomic tools and promoting regular breaks for movement.

Low back pain, a common problem in work environments, illustrates the importance of preventive ergonomic strategies. Haeffner et al. (2018) highlight the need to adapt work spaces to prevent this condition,

showing that focused changes can significantly improve workers' lives. The causes of low back pain often include poor posture, inadequate lifting of weights and a sedentary lifestyle, and its impact on the work environment is significant, leading to absenteeism and reduced productivity. This focus on prevention is essential to avoid discomfort and maintain productivity, emphasizing adjustments to the height and ergonomics of workstations, as well as training on correct lifting and moving techniques.

In the fight against tendonitis, ergonomics is a key preventative tool. Ramos et al. (2022) suggest regular reviews of tasks and the layout of workstations to prevent movements that could trigger this condition. Tendinitis, inflammation of a tendon caused by repetitive movements or overexertion, can significantly impact work capacity, causing pain and limited movement. Ergonomic adjustments are, therefore, essential to avoid this and other diseases related to repetitive work, including the reorganization of tasks to evenly distribute muscular effort, and the implementation of tools that reduce the need for repetitive movements or excessive force.

Additionally, carpal tunnel syndrome also benefits from an ergonomic approach. Judicious adjustments to the work environment and the use of tools, as discussed by Magalhães et al. (2022), can reduce the risks of this syndrome, promoting a healthier and safer work environment. This condition, characterized by compression of the median nerve in the wrist, results in symptoms such as pain, numbness and weakness in the hand and arm. Strategies to mitigate risk include adopting ergonomic keyboards and mice, adjusting desk heights to ensure wrists maintain a neutral position, and performing strengthening and stretching exercises.

Bursitis, caused by repetitive movements or continuous pressure, is yet another condition where ergonomics can act preventatively. Interventions in the design of tasks and the physical work environment are recommended to prevent this and other conditions, as pointed out by Ramos et al. (2022), demonstrating the ability of ergonomics to address a diverse range of DMEs. Promoting a variety of movements and periodically changing tasks are practices that can help prevent overload in specific areas of the body, thus minimizing the risk of bursitis, which often affects shoulders, elbows and knees, causing pain and functional limitations.

Instructing employees in ergonomic and safety practices constitutes one of the main foundations of ergonomics in the workplace. Educational programs, such as those mentioned by Haeffner et al. (2018), play a vital role in alerting employees to the need to use work methods that protect their physical integrity. Such instruction must be comprehensive, covering recommended work practices and proposing knowledge about the signs and symptoms of musculoskeletal disorders, encouraging workers to seek early interventions to prevent the exacerbation of these disorders.

The rehabilitation of individuals affected by MSDs, emphasized by Haeffner et al. (2018), highlights the need for an integrated approach, which considers adjustments in the location and way of work to facilitate the safe return of the worker. These strategies may include adaptations to the workplace, flexibility in schedules, and the gradual introduction of tasks, ensuring that the return to work is beneficial for both the employee and the employer.

Finally, the effectiveness of ergonomic measures depends on continuous monitoring of work environments and collaboration between different professionals. Early identification and remediation of potential hazards is essential to preventing DMEs and ensuring a healthy and productive work environment. Multidisciplinary collaboration, involving ergonomists, healthcare professionals, managers and workers themselves, is essential to develop and implement effective strategies for preventing and treating musculoskeletal disorders.

3.2 Cognitive Ergonomics and Mental Health

Cognitive ergonomics is a crucial area that helps look after workers' mental health, looking at important issues such as how much they need to mentally exert themselves at work, the level of stress they face and how this affects their ability to concentrate. Beckert and Barros (2022) highlight how important it is to include this area in company policies, mainly because the The COVID-19 pandemic has heightened these challenges, making the work environment even more stressful for many.

When we talk about mental health at work, we are not just talking about emotional well-being, but also how this is reflected in the physical health of employees. The way work is organized, the complexity of tasks and even the environment in which they are performed can increase mental pressure on employees. Ramos et al. (2022) argue that adopting cognitive ergonomics measures can really make a difference, making the work environment more friendly to employees' minds.

Corrêa and Silva (2009) point out that taking care of workers' minds does not only mean helping them deal with stress, but also keeping their cognitive functions healthy. This can be done in a number of ways, such as changing the way work is structured, improving workplace design, or offering programs that provide psychological support.

Developing a work environment that supports mental health requires careful consideration of the structuring of tasks, the architecture of the workspace, and the style of feedback provided. Beckert and Barros (2022) emphasize the importance of making adjustments in these areas to minimize stress and enrich employees' mental health. There is a direct link between our mental well-being and professional performance.

According to Ramos et al. (2022), being mentally healthy allows employees to face the cognitive demands of their role, highlighting the importance of taking care of mental health to maintain satisfactory performance at work.

Observing how employees deal with mental pressure is essential to avoid mental disorders and promote a viable work environment. Carrying out constant checks, as Corrêa and Silva (2009) advise, is effective in recognizing difficulties and identifying the need for reformulations, whether in tasks or in business guidelines, to promote the health and efficiency of workers.

Working together – mental health experts, ergonomists and managers – is key to creating effective workplace interventions. This collaboration helps ensure that workers' needs are met and company objectives are achieved, all in an environment that promotes health and productivity.

Incorporating practices that improve well-being and offer psychological support, aligned with cognitive ergonomics, is crucial. Ramos et al. (2022) talk about the importance of creating a culture in the company that values mental health, providing an environment where the well-being of employees is a priority. Finally, the adoption of cognitive ergonomics practices appears as a powerful resource for promoting mental health and well-being in corporate environments. The experience of renowned organizations, such as Volkswagen do Brasil, illustrates the positive impact that such practices can have by establishing a more welcoming and motivating organizational climate. In this way, cognitive ergonomics is established as a pillar in the design of work spaces that value both productive efficiency and the psychological well-being of its members. Well-designed ergonomic strategies, what consider you aspects mental It is emotional of theemployees, are vital to organizational success and the perpetuation of a conducive and sustainable work environment.

3.3 Organizational Ergonomics and its Importance

Organizational ergonomics is a type of macroergonomics, through the understanding of organizational culture, work projects, human resource management, quality management and the organization of networks and communication, and the optimization of technical systems is among its main characteristics. , organizational structure, withLaw Suitand consolidated internal policy.

Organizational ergonomics is the structure and everything it encompasses in an organization, whether a company or institution, with regard to improving employees' working conditions. The most relevant factor in this area of ergonomics is communication between people, their policies, cooperation, networking and quality management in processes. Organizational ergonomics aims to optimize socio-technical systems, including organizational structures, policies or rules, and processes (FERREIRA; MERINO; FIGUEIREDO, 2017).

Thus, in the organizational context, it is essential that there is an accurate perception of the risks and ergonomic factors associated with work, whether in the countryside or in the city (RIO; PIRES, 2001). For Fernandes and Morata (2002, p. 706):

> Organizational stressors are factors related to work organization, such as shifts, rhythm and ergonomics, that is, the worker's relationship with their tasks. They alter the functioning of the entire organism and sleep, increase sensitivity to environmental stressors and, consequently, increase the risk of accidents at work. Combined, these stressors can have a range of effects on workers' health and well-being.

According to Martins and Ferreira (2015), among the different contexts in which Ergonomics can act, rural work is one of them. Agricultural activity is extremely important and also complex, and can result in a variety of accident and illness risks for rural workers. Such risks are present throughout the production process carried out in the field.

In this context, the Ministry of Labor and Employment, through Ordinance No. 3,214, of June 8, 1978 (BRASIL, 1978), created and is constantly reviewing regulatory standards (NR), which regulate and provide guidance on mandatory procedures related to Safety and occupational health. Among them are:

> NR 17 — Ergonomics, which aims to establish parameters that allow the adaptation of working conditions to the psychophysiological characteristics of workers, in order to provide maximum comfort, safety and efficient performance. Added to this, NR 31 — Safety and Health at Work in Agriculture, Livestock, Forestry,

> Forestry and Aquaculture — establishes the precepts to be observed in the organization and in the work environment, in order to make planning and work compatible development of agriculture, livestock, forestry, forestry and aquaculture activities, with safety, health and the work environment. According to this NR, rural or similar employers must plan health and safety actions aimed at preventing accidents and illnesses resulting from work in the rural production unit, taking into account the following order of priority: a) elimination of risks through replacement or adaptation production processes, machines and equipment; b) adoption of collective protection measures to control risks at source; c) adoption of personal protection measures. Still, it cites the need for employers to adopt ergonomic principles to improve comfort and safety conditions at work for their employees.

IV. MENTAL HEALTH AND ITS INFLUENCES ON ORGANIZATIONS

Mental health influences organizations and the lives of workers. In an organizational scope, that is, within companies, there is a notable influence exerted by the mental health of each employee within the organization, which consequently ends up affecting the level of productivity and profitability (SILVA, 2014).

According to Bergamini (1982, p19),

> "One of the aspects of human behavior whose study has been most encouraged today is that which seeks to understand how people live and solve their problems within their work context. Unlike technology, finance and commercialization, company management has made it clear that the human element is characterized as a preponderant factor in facilitating or compromising the achievement of organizational objectives".

Each organization is unique, each one has its own rules to be followed, objectives to be achieved by particular means to which they adhere, however they are all made up of even a small or large number of human beings in their composition.

According to Aguiar (1992, p 230),

> "The members of the organization group together to carry out organizational activities and relate to each other. As human beings, they bring their feelings, motivations, aspirations, values, skills, etc., to the organization. The organization develops its own culture, its behavior patterns, its beliefs and habits, common to all its members. All these factors interact. They are interdependent and influence each other. The organization, as a social environment, is a dynamic set of interacting factors, influencing the development of the individual characteristics of its members".

The influence exerted by organizations on their members is very strong, it does not influence everyone equally in the same way, but it ends up shaping everyone in some way. This influence conditions these members to add more ways to their personal ways of acting, often completely changing their way of being, or just leaving this new way as another optional way of acting on some specific occasion (SILVA, 2014) .

According to Silva (2014), within organizations, in the same way that one seeks to focus on the quality of the product or service offered, meet goals, increase sales, put pressure on employees, create a marketing plan, publicity, among others, one must Also focus on the progress of your employees' psychological condition. The psychological framework, the study of psychological theory is essential and is a requirement for an administrator or organization that has to deal with the most varied types of people on a daily basis.

According to Leavit (1972), studying mental health should be like rice and beans within organizations and for an administrator. Because with this added knowledge it is possible to see, predict and guard against problems caused by employees due to their mental states.

Companies are made up of human beings in their entire scope, each human being is unique, singular. There are days when someone is in a good mood, and other days when they are in a bad mood. These fluctuations in individual behavior directly interfere with the company's production. The correct and desired thing is for all employees to be proactive, to be leaders, to be diligent, to work hard, to sweat and to wear the company's shirt, body and soul. Every company aims to have an effective workforce, a framework in which all members of the organization have a good mental programming, which is the most conducive to generating good productivity (SILVA, 2014).

According to Brgamini (1982, p 24),

> A person becomes a problem within an organization whenever their behavior creates difficulties for the group of people in which they carry out their activities or in view of the

company's rules, including all business policies, whether administrative, technical or financial. . The problem employee draws attention for his atypical and often undesirable conduct, eventually causing a complaint about his way of acting. The "complaint" is therefore the current symptom, but to prove itself as such, the individual has gone through and accumulated a series of previous incidents. By exhaustively surveying these elements and studying their connection with the current complaint, it will be possible to formulate a diagnosis of the behavior and predict what future measures will be taken.

According to Silva (2014), among others, some of the negative influences of mental health on employees are: frustration, rationalization and fixation. The same author also cites some positive influences of mental health in the organization, such as the mental state of motivation and the mental state of leadership.

Mental health directly affects the decisions that human beings make on a daily basis. It can be said that everything that happens in the lives of human beings is what they attract to themselves. That is why it is necessary to take care of the mind, manage it effectively so that it does not lose control and end up being harmed.

The conditions and demands of the current job market impact workers' mental health in different ways. In addition to their immediate relationship with the work itself, what affects the psyche of workers are precarious work relationships, such as job instability, partial and/or temporary contracts, subcontracting, etc. Such precarious relationships are present in the reality of citrus workers, which requires a look at the connection between mental health and work, as the process of becoming ill is specific to each individual and involves their daily lives. It is important to highlight that, in addition, these workers suffer from exclusion from attention due to the failure to achieve actions developed by the worker health care network (SANTOS; MENTA, 2016).

V. INFLUENCE OF ERGONOMICS ON EFFICIENCY AND ORGANIZATIONAL PERFORMANCE

The incorporation of ergonomic principles in work environments goes beyond the mere promotion of the health and well-being of employees, having a significant impact on the efficiency and performance of organizations. Research carried out by Pinto, Tereso and Abrahão (2018) in the Metropolitan Region of Campinas shows how the implementation of effective ergonomics is directly correlated with increased productivity and improved performance in industries. This link highlights ergonomics not only as a preventive health measure, but also as a strategic vector for business growth and competitiveness.

The customization of workspaces, as addressed by Villarouco and Andreto (2008), emphasizes the ability of ergonomics to optimize organizational performance by adapting the environment to the specific needs of employees. This personalization enhances productivity, creating a work environment that motivates and inspires, while ensuring the health and comfort of employees. Thus, ergonomics presents itself as a valuable resource for promoting a stimulating and effective workplace.

Considering ergonomics as an interdisciplinary discipline that aims to adapt work to human beings, it seeks not only to prevent health problems, but also to optimize employee satisfaction and performance. Ilda (2005) reinforces this vision by demonstrating how well-planned ergonomic interventions contribute to a more engaged and productive workforce, highlighting ergonomics as a lever for continuous improvement in organizational performance.

Preventing workplace accidents and minimizing injuries are key components of ergonomics that have a direct impact on organizational efficiency. The guidelines provided by NR 17 (BRASIL, 2021) exemplify how the elimination of ergonomic risks contributes to a safer and, consequently, more productive work environment. This enhanced security not only protects employees, but also reduces operational costs related to sick leave and injury treatments.

Promoting quality of life at work through ergonomic practices is intrinsically linked to increased employee satisfaction. A healthy and comfortable workplace reduces stress and fatigue, which positively influences team motivation and efficiency. Therefore, ergonomics plays a key role in creating an environment that supports employees' physical and mental health, while boosting their disposition and performance.

Finally, the inclusion of employees in the development and implementation of ergonomic solutions ensures that interventions are practical and meet the real needs of workers. This direct involvement promotes not only the technical effectiveness of the proposed solutions, but also their acceptance and integration into the organizational culture, resulting in a more harmonious and productive work environment. Ergonomics, therefore, emerges as an essential strategic field for organizations that seek not only to increase their productivity, but also

to enrich the quality of life of their employees, demonstrating tangible benefits that range from employee well-being to substantial gains in efficiency. and market competitiveness.

VI. WORKPLACE ERGONOMICS IMPLEMENTATION STRATEGIES

The effective implementation of ergonomic strategies in work environments plays an important role in promoting health and increasing employee productivity. Recent research, such as Brasil (2020) and Thaís (2023), highlight success stories, such as Volkswagen do Brasil, where the adoption of such strategies resulted in a reduction in problems related to occupational health. The objective of ergonomics is to configure work to adjust to the capabilities and limitations of the human being, highlighting the relevance of a work environment that is both healthy and efficient. New approaches and studies in this field have expanded the understanding that well-planned ergonomic practices can lead to a substantial increase in well-being and organizational efficiency.

As pointed out by Oliveira et al. (2011), the Ministry of Labor and Employment highlights the importance of synergy between employers, employees and government entities. This synergy is essential so that ergonomic initiatives are not only implemented, but also sustained over time, integrating them effectively into occupational health and safety policies. The interaction between the various stakeholders guarantees a comprehensive and efficient approach to ergonomics in the work context, emphasizing the need for effective communication and mutual commitment to the success of the strategies adopted.

The effectiveness of ergonomic strategies also depends on the incorporation of cutting-edge technologies and validated methodologies, which must be adapted to the particularities of each work environment. In this sense, Filho and Lima (2015) emphasize that technological innovation in ergonomics can catalyze substantial improvements in working conditions, helping to prevent occupational injuries and illnesses. The integration of new digital tools and data-based solutions can enhance the application of ergonomic measures, making them more precise and personalized.

Furthermore, continuing education in ergonomics is essential to foster a preventive culture in work environments. Ferreira (2015) highlights that training and awareness in ergonomic principles and practices induce positive changes in work routines, mitigating risks and cultivating a safer and healthier working space. The expansion of these educational initiatives, covering different hierarchical levels of the organization, can reinforce the importance of ergonomics and encourage more active and informed participation from all employees.

The active inclusion of employees in the process of creating and implementing ergonomic solutions ensures that the measures adopted are relevant and effective. This participation promotes solutions that are not only technically appropriate, but also culturally resonant, harmonizing ergonomic interventions with the organization's reality and values. The development of communication channels that allow continuous feedback from employees can enrich ergonomic initiatives, ensuring that they are both innovative and aligned with employees' needs (FILHO; LIMA, 2015).

Integrating ergonomic considerations in the design of tools, equipment and spatial arrangements provides benefits that transcend the well-being of workers, and can also enrich the experience and safety of consumers. Natura's approach, mentioned in NATURA (2022), exemplifies how ergonomic design can constitute a strategic advantage. The company demonstrates a commitment to innovation by applying ergonomic principles not only in the work environment, but also in the development of its products, considering the well-being and experience of the end user.

Continuous evaluation and monitoring of ergonomic practices is vital to confirm their effectiveness and promote constant improvements. These periodic analyzes are essential to understand the impact of these practices on employee well-being and productivity, contributing to the durability of ergonomic initiatives. Implementing monitoring systems that use advanced technologies can offer more accurate and timely insights into the effectiveness of adopted ergonomic strategies (SARMENTO; VILLAROUCO, 2020; BRASIL, 2021).

In summary, the adoption and success of ergonomic strategies requires a multifaceted and integrated approach, which addresses both technical and human aspects, aligning with pre-existing health and safety policies. Dedication at all organizational levels and continuous adaptation to employee demands and feedback are crucial to ensuring an optimized and healthy work environment. The integrated and holistic approach, considering the interaction between individuals, tasks and the work context, is fundamental to the success of these strategies, positively reflecting on productivity and job satisfaction.

VII. ERGONOMIC ENGINEERING AND WORKPLACE DESIGN

The integration of ergonomic engineering and workplace design is critical to creating environments that promote worker health, safety and efficiency. Batagin (2017) and Lima and Duarte (2014) highlight the importance of incorporating ergonomic principles from the initial phases of design, allowing the anticipation and prevention of problems, thus avoiding later corrections. The Ergonomic Workplace Analysis (EWA) methodology, cited by Batagin, enables a systematic and detailed assessment, fostering continuous and sustainable improvements.

Ferreira's (2015) contribution enriches the dialogue on ergonomic engineering, highlighting Activity Ergonomics as an essential pillar to improve Quality of Life at Work. This methodology transcends the superficial analysis of the work environment, delving deeply into the interactional dynamics between the worker and all aspects of their work environment. This holistic approach takes into account not only physical elements, such as the arrangement of furniture and equipment used, but also investigates organizational structures, such as company culture, workflows and interpersonal relationships, in addition to social aspects, which they encompass social support, perception of role at work and occupational stress.

By focusing on Activity Ergonomics, an integration is proposed that goes beyond mere physical ergonomic adaptation, advocating for a work design that is intrinsically adapted to human characteristics, thus promoting environments that not only prevent occupational injuries and illnesses, but that also they catalyze job satisfaction, motivation and, therefore, productivity. This focus on an integral approach allows us to identify and shape working conditions so that they align with the needs, capabilities and expectations of workers, resulting in significant improvements in the quality of life at work, which are directly reflected in organizational efficiency and effectiveness (FERREIRA , 2015).

Lima and Duarte (2014) deepen the understanding of ergonomics in the work context by introducing the concept of "use configurations". This innovative approach is not limited to preventing occupational illnesses; it seeks to optimize the well-being and performance of workers. "Configurations of use" propose the creation of jobs that are adaptable to technological changes and developments in work practices, creating a dynamic environment that favors both the professional and personal development of employees.

The active participation of workers in the design of workstations is emphasized by Lima and Duarte (2014) as a pillar for the success of ergonomic interventions. This participation ensures that the solutions adopted effectively reflect the needs and preferences of end users, resulting in significant improvements in quality of life and productivity at work.

Batagin (2017) highlights the importance of universal design in the creative process, ensuring that workstations are accessible and usable by everyone, regardless of their physical capabilities or health conditions. This inclusive approach is fundamental to ensuring equity in the workplace.

On the other hand, Ferreira (2015) highlights the relevance of cognitive ergonomics and its impact on reducing cognitive load and improving the psychological well-being of workers, expanding the understanding that quality of life at work transcends physical aspects.

Lima and Duarte (2014) offer a comprehensive vision when integrating sustainability into workplace design, arguing that this incorporation is not just an environmental necessity, but an extension of ergonomics itself. By establishing a direct connection between workers' well-being and environmentally responsible practices, the authors argue that a truly sustainable work environment goes beyond environmental conservation, also addressing social and economic sustainability.

In this context, sustainability in jobs is seen as a triple commitment that includes economic viability, social equity and environmental protection. By integrating these three pillars into ergonomic design, Lima and Duarte (2014) propose a work environment that is not only healthy and productive for workers, but also contributes to the preservation of environmental resources and promotes social justice.

The approach suggests that jobs designed with sustainable considerations can result in benefits such as reduced waste, lower energy and resource consumption, as well as fostering a more positive organizational climate, where workers feel valued and part of an ethical business culture. is responsable.

Another important point to consider is the continuous monitoring and adaptation of workstations, which are essential to maintain the relevance and effectiveness of ergonomic interventions in the face of technological changes and new work dynamics, as discussed by Batagin (2017), Ferreira (2015) and Lima and Duarte (2014).

Continuous training in ergonomics, as highlighted by Ferreira (2015) and Lima and Duarte

(2014), is a key element in the development and maintenance of jobs that are not only safe and efficient, but also adaptable to rapid and constant changes. in the world of work. This continuous learning process allows ergonomists and other professionals related areas understand and apply the latest research, technologies and methods in the design, evaluation and improvement of work environments.

By committing to ongoing education, ergonomics professionals can better respond to new questions arising from technological advances, organizational changes, and new understandings of occupational health and worker well-being. This includes staying abreast of the latest trends in analytical tools, ergonomic simulation software, as well as new industry regulations and standards.

Ferreira (2015) and Lima and Duarte (2014) argue that such training not only benefits individual ergonomists, but also organizations and their employees, as it promotes more adaptive, productive and, crucially, more humane work environments. By staying up to date, the ergonomist can effectively advise on modifications to the work environment that promote not only health and safety, but also worker engagement and satisfaction.

Continuing training also prepares professionals to proactively address emerging ergonomic risks, rather than reacting to them after they become problems. This translates into a more strategic and less costly approach to managing occupational health and safety, aligning work practices with long-term organizational sustainability and efficiency goals.

VIII. WORK SYSTEMS AND HUMAN-MACHINE INTERFACE

In Civil Engineering, work systems and human-machine interfaces have evolved significantly, driven by the advancement of technologies and the need to optimize processes, increase safety and improve the quality of constructions.

The integration of information and communication technology (ICT) on construction sites, as discussed by Oliveira and Serra (2017), transforms significantly the management of safety equipment in civil engineering. The use of RFID technology, as exemplified in the control of security equipment, illustrates the ability of ICTs to automate and optimize processes, reducing the incidence of human errors and increasing operational efficiency. This technology allows for precise, real-time monitoring of resources on the construction site, promoting more effective and proactive management in the maintenance and use of safety equipment. Figure 1 illustrates the components of an RFID system. The reader emits radio signals continuously at a given frequency. When a Tag, previously adjusted to identify the working frequency in use, interacts with these signals, it is activated and establishes communication with the reader through modulation of transmittance frequencies. The reader, in turn, captures and interprets this data, forwarding it to the system to which it is linked, allowing it to recognize the communication protocols on a computer.

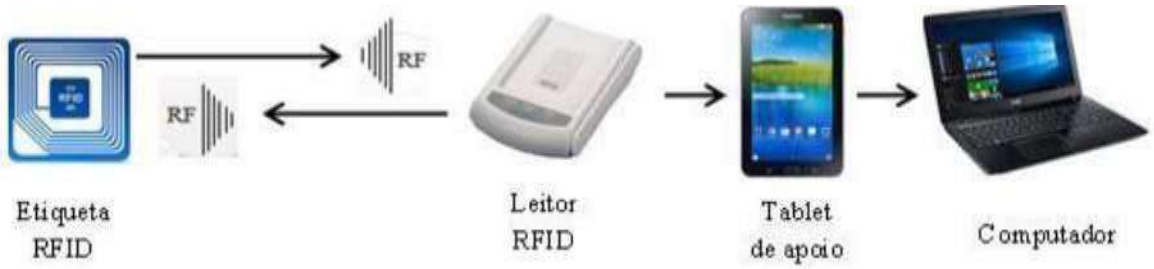

Fig.1 – RFID System Components. Source: OLIVEIRA et al. (2011)

By detailing the implementation and benefits of the RFID system on construction sites, the study reveals how ICT can contribute to better organization, tracking and management of resources, fundamental elements for safety and productivity in construction. Technology allows you to quickly identify the location and status of equipment, providing essential data for immediate and strategic decisions, emphasizing the relevance of adapting such technological innovations to improve conventional practices in the sector (OLIVEIRA et al., 2011)

The article by Oliveira et al (2011) highlights the application of RFID technology (Radio Frequency Identification) in monitoring and controlling safety equipment on construction sites. The implementation of this technology allows for more effective equipment management, contributing to safety and productivity. By

automating tracking and control, human errors are reduced and the use of resources is optimized, demonstrating a significant advance in human-machine interaction in civil engineering.

On the other hand, ergonomics, as discussed by Soares (2009), plays a fundamental role in designing safer and more efficient work environments. The integration of ergonomic principles into work systems and human-machine interfaces in civil engineering not only improves worker well-being, but also increases operational efficiency. Ergonomics considers human limits and capabilities, aiming to adapt work, equipment and the environment to people, which results in greater productivity and fewer workplace accidents.

The interaction between humans and machines is increasingly mediated by digital interfaces, which allow more precise and intuitive control of equipment. These interfaces are designed with usability in mind to ensure that they are understood and used efficiently by operators, regardless of their level of familiarity with the technology.

The research by Prysthon, Schmidt and Silveira (2006) reinforces the idea that engineering produces solutions that are used by society, highlighting the importance of applied research in solving concrete problems. In that context, the human-machine interface in civil engineering is not limited to the construction site, extending to project management, planning and design, where data-driven decisions and information modeling build a bridge between theory and the practice.

The integration of Augmented Reality (AR) in civil engineering, as discussed in the article by Silva et al. (2020), offers a wide range of benefits and possibilities, particularly in improving ergonomics in the workplace. AR, by combining elements of the real environment with data and virtual models, provides a more intuitive and efficient interaction between professionals and the project or construction they are working on.

The application of AR in civil engineering can significantly improve spatial understanding and technical details of projects, allowing professionals to visualize structures, facilities, and potential problems in a more immersive and interactive context. This not only facilitates the identification and resolution of problems more quickly and effectively, but also contributes to reducing the risk of errors and accidents in the workplace, thus promoting a safer and ergonomically optimized environment (SILVA et al., 2020).

Additionally, AR can be used to simulate different construction scenarios, allowing engineers and builders to visualize changes and adapt their plans before physical implementation. This results in more flexible and adaptable work processes, which can better respond to workers' ergonomic needs, minimizing unnecessary efforts and improving overall efficiency (SANTOS, 2023).

The training and training of professionals also benefit greatly from AR, as it allows them to simulate complex or dangerous work situations in a controlled and safe environment. This can improve workers' preparation and response to real working conditions, increasing safety and promoting ergonomically favorable work practices (SALGADO et al., 2020).

Therefore, the integration of AR in civil engineering represents a significant advancement in the way projects are visualized, planned and executed, offering a powerful tool to improve ergonomics, safety and efficiency in the workplace. The possibilities that open up with the use of this technology have the potential to fundamentally transform the construction industry, aligning it with the principles of ergonomics and maximizing the well-being and productivity of workers (RAIZ, 2024).

IX. CIVIL CONSTRUCTION AND ERGONOMICS

Civil construction is one of the industry sectors where workers are most exposed to various risk factors, as well as to accidents at work, that is, they are more prone to occupational risks (SILVA et al., 2016).

> Silva et al. (2016, p.39) defines occupational risks as those where:
>
> > Professionals will be exposed to dangerous and unhealthy activities, having a direct relationship with working conditions, methods used and risk agents to which they are exposed, such as chemical, physical, biological and mechanical agents, subjecting them to possible adverse health effects of the worker.

For the good performance of construction work in an ergonomic manner, it is necessary to consider NR 17. This regulatory standard provides guidelines so that there are adaptations in working conditions to the psycho-physiological characteristics of workers, while ensuring comfort, safety, quality life and efficient performance.

NR nº 17 establishes standards for work activities regarding transport, furniture, equipment, environmental conditions and work organization. According to the NR 17 application manual, it is necessary to provide adaptations to the working conditions and environment, considering the psycho-physiological conditions of the

worker, ensuring that they carry out their activities in a comfortable way and that ensures physical well-being and quality of life.

9.1 Some innovations in the construction industry

We can say that the more technology advances, the greater the opportunities for ergonomics, as such innovations result in less effort, greater adaptation and, consequently, better working conditions.

Below are some innovations that are already in use on construction sites here in Brazil. These are creations that a few years ago would have been something out of a science fiction film, but that today are already contributing to faster, cheaper and, obviously, more ergonomic constructions:

a) Mechanical leg: The equipment is nothing more than legs similar to those we used when we were children (Figure 2). The worker goes through a period of training until he is able to balance safely and from then on the gains are incredible, as the work can be done much faster, without the need for ladders or scaffolding.

Fig.2 – Mechanical legs used in civil construction. Source: ERGOTRIADE (2021)

b) Floor leveler: That scene of 10, 20 men squatting or kneeling with trowels leveling large areas of floor is already a thing in many construction companies. Using a single operator and only 10% of the time, this machine levels large areas of flooring. The equipment was developed in the United States and is already in use in Brazil (Figure 3).

Fig.3 – Floor leveler used in construction. Source: ERGOTRIADE (2021)

c) Plastering and plastering machine: Using compressed air, this invention is capable of plastering up to 30 m^{two} per hour. In addition to guaranteeing time savings, it avoids manual work which, in this activity, usually

represents an ergonomic risk (Figure 4).

Fig.4 – Plastering and plastering machine used in construction. Source: ERGOTRIADE (2021)

d) Painting equipment: This is the evolution of compressed air painting systems (Figure 5). In addition to representing important gains in productivity and ergonomics, it also prevents the dispersion of paint in the air, which significantly reduces risks to worker health.

Fig.5 – Painting equipment used in construction. Source: ERGOTRIADE (2021)

X. THE IMPORTANCE OF ERGONOMICS FOR THE HEALTH OF THE COMPANY AND ITS EMPLOYEES

Understood as a discipline that harmonizes the work environment with human needs, ergonomics goes beyond preventing health problems, also aiming to increase employee satisfaction and performance. In this context, Ilda (2005) strengthens this concept by illustrating that carefully planned ergonomic actions not only encourage team engagement and productivity, but are also effective tools for constantly increasing organizational efficiency. Therefore, ergonomics is established as an integral approach, which not only protects the well-being of employees, but also contributes significantly to business evolution and success.

The incorporation of ergonomics from the initial stages of design and planning of work spaces appears as a crucial strategy, which can prevent the need for future modifications, which are often more costly and less effective. Furthermore, organizational engagement with Ergonomics needs to be intensified, requiring leaders and managers to recognize its value not only for the health of employees, but also for the performance and sustainability of companies.

The development and expansion of educational programs in ergonomics are fundamental and must cover all hierarchical levels of organizations. Promoting understanding about ergonomics and its relevance must be an essential component in the training of all employees, from senior management to operational levels.

Advances in cognitive ergonomics signal a future where mental health will receive as much attention as physical health. Organizations will need to be prepared to implement strategies that consider both aspects, ensuring a holistically healthy work environment.

Research in ergonomics, aimed at discovering new spheres and facing recent challenges, is essential for the evolution of this science. The integration of varied fields of study, such as psychology, design, engineering and public health, can significantly increase the quality of ergonomic interventions, making them exceptionally comprehensive and creative. By adopting participatory ergonomics strategies, which include employees in the development and evaluation of ergonomic measures, not only an increase in their effectiveness is expected, but also an increase in engagement and acceptance on the part of employees. Legal and regulatory factors will also continue to exert a significant influence on the fate of ergonomics, with compliance with current legislation and active contribution to the creation of standards that favor healthier work practices being essential.

XI. GENERAL CONSIDERATIONS

The study carried out shows the importance of applied research to strengthen ergonomic practice in organizations. The future of ergonomics is intrinsically linked to its ability to adapt and respond to new challenges, maintaining the commitment to promoting work environments that prioritize and cultivate human well-being.

In short, ergonomics must remain focused on the human element, ensuring that technological innovations and organizational changes are consistently evaluated considering their impacts on the health, well-being and efficiency of workers.

It is important that managers, from all sectors, are aware that providing an occupational health and safety program and investing in ergonomic projects in the organization is not just a legal obligation. This measure can increase the productivity and performance of workers, reducing the rates of absences due to occupational illnesses.

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Attention Deficit Disorder with Hyperactivity in the Academic Cycle: An Integrative Review on Study Techniques that Favor Learning

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***Keywords*— Learning; University education; Attention Deficit Hyperactivity Disorder.**

***Abstract*—** *Attention Deficit Hyperactivity Disorder is a neurological condition that begins to manifest itself in childhood and continues to affect the individual throughout development. It is associated with a series of hyperactive and impulsive behaviors that are observed daily by those who live with people affected by this disorder. The predominant symptoms are inattention and hyperactivity-impulsivity, which have widespread impacts on the daily lives of individuals with the disorder. The present work consists of an integrative review, which aims to discuss study techniques that favor learning in the academic cycle for people with attention deficit hyperactivity disorder, through considerations about it and its impact on academic life. . This is an integrative review, in which basic, qualitative, exploratory and bibliographic research was carried out in the following databases: Pubmed, MedlinePlus, Scientific Electronic Library Online (Scielo – Scientific Electronic Library Online) and Google Scholar. Learning strategies are methods that students use to build knowledge, aiming to facilitate the acquisition and storage of information. These techniques can be grouped into three main categories, namely: Cognitive Strategies, which include rehearsal, elaboration and organization of information; Metacognitive Strategies, which involve planning, monitoring and regulating the learning process itself; Resource Management or Affective Strategies, which deal with time management, study environment, effort and seeking external support. In short, learning strategies, which encompass cognitive, metacognitive and affective aspects, play an essential role in the educational process, providing students with tools to acquire knowledge in an effective and autonomous way. However, the effectiveness of these strategies depends on psychological and motivational factors, and educators play a crucial role in encouraging the development of these skills, promoting self-regulation and critical thinking. Therefore, mastering these strategies empowers students to become successful, autonomous learners throughout their lives.*

I. INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a neurological condition that begins to manifest itself in childhood and continues to affect the individual throughout development. Ferreira (2011) describes that this is associated with a series of hyperactive and impulsive behaviors that are observed daily by those who live with people affected by this disorder. The predominant symptoms are inattention and hyperactivity-impulsivity, which have widespread impacts on the daily lives of individuals with the disorder.

Mattos et al. (2006) explain that ADHD begins in childhood, but can persist into adulthood, causing a series of challenges in the social, professional and, in particular, academic spheres. Trevisan et al. (2021) reinforce that, although there is greater concern about identifying ADHD in children, the prevalence of this disorder in adults is significant, with profound implications for the teaching and learning process, especially in the academic environment. Furthermore, Barreto and Guimarães (2021) highlight that individuals with disorders or disabilities often do not receive adequate attention, which can result in school failure.

It is important to highlight that diagnosing ADHD in adults can be challenging, as the symptoms are often mistakenly associated with psychological problems, as mentioned by Castro and Lima (2018). In the academic context, lack of attention, low performance and dispersion are common and can have adverse consequences for individuals, since many people who do not understand the disorder tend to interpret these symptoms as indiscipline or laziness (TICAS; UCHOA, 2010).

As observed by Silva et al. (2021), the beginning of academic life brings with it several significant changes, including a new social environment, a more hectic routine and a series of pressures regarding the future career. Furthermore, university students in the health field often do not receive adequate training in mental health and face stressful situations on a daily basis, which can lead to mental health problems, risk of suicide and difficulties in caring for patients. .

ADHD in adults is often considered a camouflaged condition due to its ability to mask symptoms, resulting in interpersonal relationship problems, disorganization, mood swings, substance abuse, and comorbidities. This makes diagnosis challenging, especially for women, who are often not diagnosed or treated properly. However, early diagnosis and appropriate treatment can significantly reduce symptoms (LOPES; NASCIMENTO; BANDEIRA, 2005).

Adults with ADHD often report problems with disorganization, difficulty concentrating, forgetfulness, difficulty completing tasks, chronic feeling of activity overload and inability to plan the future. These symptoms can harm academic and social performance, affecting communication and social participation, in addition to academic success (LEMOS; LOPES; SOBREIRA, 2021).

Research related to ADHD in adults, especially in college students, is a relatively recent field. Studies indicate that around 2% to 8% of young adult students report experiencing clinically relevant symptoms of the disorder. These academic difficulties can affect individuals' self-image, making them more introverted and leading to social isolation. Furthermore, they may be at risk of completing their courses successfully or may take longer to graduate compared to their peers without the disorder (LOPES; NASCIMENTO; BANDEIRA, 2005).

The present work consists of an integrative review, which aims to discuss study techniques that favor learning in the academic cycle for people with attention deficit hyperactivity disorder, through considerations about it and its impact on academic life. .

II. METHODOLOGY

The work consists of an integrative literature review, which is characterized as a modality that enables a broad methodological approach regarding reviews. In this type of review, a diversity of research is included, such as experimental and non-experimental, which allows an understanding of the phenomenon analyzed, also combining data from theoretical and empirical literature (SOUZA; SILVA; CARVALHO, 2010).

To this end, basic, qualitative, exploratory and bibliographical, in the following databases: Pubmed,*MedlinePlus*, Online Scientific Electronic Library (Scielo –*Scientific Electronic Library Online*) and Google Scholar. To this end, the following descriptors registered in the Health Sciences Descriptors (DeCS) were used: Learning; University education; Attention Deficit Hyperactivity Disorder. Afterwards, the appropriate crossings were carried out, using the Boolean operators AND and OR.

The following inclusion criteria were used: articles, monographs, dissertations and theses that addressed the topic in question, all published in Portuguese and English, and that were available in full in the databases used. And, as exclusion criteria: works in formats other than those mentioned above, research published in languages other than those mentioned above, which did not address the topic and which were not available in full in the databases already mentioned.

III. ATTENTION DEFICIT DISORDER WITH HYPERACTIVITY

ADHD is a chronic clinical disorder, widely recognized by professionals in the field. Both the international classification system, the International Statistical Classification of Diseases and Related Health Problems (ICD-10), and the Diagnostic and Statistical Manual of Mental Disorders (DSM-V), identify it as a set of symptoms that affect individuals. from the initial phase of development and extends into adulthood. These symptoms, characterized by attention deficits, hyperactivity and impulsivity, have been identified as one of the main causes of academic failure in the Brazilian context, becoming a public health problem (ARGOLLO, 2003).

To treat ADHD, neurotransmitter-stimulating drugs have been considered the most effective approach. These substances, supposedly absent in certain synapses in individuals with the disorder, include methylphenidate, sold as Ritalin and Concerta. Although there is ongoing research, there are still significant gaps in the understanding of ADHD, which makes social interaction, academic performance, and development for these individuals challenging (CALIMAN, 2008).

Historically, ADHD was initially called minimal brain injury, in Brazil in the 1940s and 1960s, to describe symptoms associated with school failure. In the 80s and 90s, there was greater global awareness about it, and methylphenidate was introduced as a treatment. In 1994, ADHD was officially recognized as a disorder in the DSM-V. This historical view helps to contextualize its current presence in culture, both in the educational system and in the pharmaceutical industry (COUTO; MELO-JÚNIOR; GOMES, 2010).

Given that development plays a crucial role in observing ADHD, analyzing this aspect can help in identifying the disorder. Symptoms include difficulty concentrating, agitation, disorganization, frequent loss of materials and other behaviors that make school life difficult and can lead to academic failure. Argollo (2003) highlights the importance of psychotherapy, medication administration and parental guidance in effective management. In the school environment, strategies such as short activities interspersed with physical exercise are recommended.

The diagnosis of ADHD generally occurs around the age of seven and is based on reports from parents and professionals who interact with the child at school. However, it is a clinical diagnosis that depends on current symptoms, especially in children, or a combination of current symptoms and clinical history in adults. In recent years, there has been a movement towards multidisciplinary diagnosis, although there is still a lack of comprehensive investigation of the possibilities for learning regardless of behaviors that do not fit the pattern (GOMES et al., 2007)

The treatment of ADHD is multimodal, involving psychosocial and psychopharmacological interventions. School has been a fundamental place for observing symptoms, as the inability to perform certain tasks opens up space for investigation of the disorder. However, issues such as dependence on medications and their side effects have generated debates about educational practices and child development (GOMES et al., 2007).

Some theoretical approaches suggest that child psychopathology emerged to meet society's demands in search of a perfect child. This led to the development of diagnostic categories in the DSM-V and the emergence of new forms of treatment and drugs to make children fit this social ideal.

IV. IMPACT OF ATTENTION DEFICIT DISORDER WITH HYPERACTIVITY ON THE ACADEMIC CYCLE

The topic in question represents a challenge for some people, as, over time, individuals tend to adapt their lifestyle and choose professions or work roles that suit their personal difficulties. The main symptoms of ADHD can have a significant impact on people's academic lives. As confirmed by Advokat et al. (2011), this issue has been the subject of studies, both nationally and internationally.

Impulsivity, inattention and hyperactivity can affect the academic's ability to manage their time and tasks, as mentioned by Rabiner et al. (2008). According to Oliveira (2017), university students face challenges in academic adaptation, and those with ADHD often experience difficulties in reading, writing, social interaction in the classroom, relationships and impaired self-esteem. Lack of concentration, reluctance to read and difficulties in understanding represent additional obstacles in the lives of people with this disorder.

Barkley (2002) and Mattos et al. (2003) observe signs of impairment in executive functions, particularly in analysis and synthesis. Although reading and writing can be challenging for students with ADHD, these skills are essential for participation in society.

However, the need for college students with ADHD to acquire knowledge related to their areas of study or information about their courses can be a major challenge, as they may lack the support necessary to organize and plan the use of information specific to their areas (RABINER et al., 2008).

Symptoms of anxiety and depression tend to increase among students with ADHD due to the difficulties

encountered at the institution. Furthermore, the lack of support from colleagues to deal with these issues, as pointed out by Masini and Bazon (2005), makes the situation even more difficult. In the Brazilian context, some teachers report difficulties in implementing the inclusion of students with ADHD, as they often lack professional preparation in psychological, pedagogical and technical aspects.

Inclusion is not a mere idea; it materializes as educators believe that their pedagogical practices can be transformed into planning, attitudes, actions and evaluations. This way, the student can learn at their own pace, which is essential for dealing with the specific demands of ADHD.

V. ADAPTED STUDY TECHNIQUES FOR ATTENTION DEFICIT DISORDER WITH HYPERACTIVITY

Learning strategies are methods that students use to build knowledge, aiming to facilitate the acquisition and storage of information. These techniques can be grouped into three main categories, namely: Cognitive Strategies, which include rehearsal, elaboration and organization of information; Metacognitive Strategies, which involve planning, monitoring and regulating the learning process itself; Resource Management or Affective Strategies, which deal with time management, study environment, effort and search for external support (BORUCHOVITCH, 1999).

Specifically, cognitive strategies refer to behaviors and thoughts that influence the learning process in order to make information storage more efficient. They can be subdivided into rehearsal strategies, which involve the active repetition of the material to be learned through writing or speaking; elaboration strategies, which consist of establishing connections between the content to be learned and previous knowledge; and organization strategies, which seek to create subdivisions in a structure to identify relationships between concepts (BORUCHOVITCH, 1999).

On the other hand, metacognitive strategies are procedures that individuals employ to plan, monitor, and regulate their own thinking. They can be grouped into planning strategies, which encompass the organization and programming of study activities; monitoring strategies, related to the capacity for self-reflection and the evaluation of the learning process itself; and regulation strategy, which cover the coordination of the functioning of the learning process.

Affective strategies, finally, are related to the management of unpleasant feelings that can harm the learning process, such as anxiety, motivation and study environment. As Boruchovitch (1994) notes, the effective use of learning strategies generally depends on psychological and motivational factors.

VI. CONCLUSION

Learning strategies, which encompass cognitive, metacognitive and affective aspects, play an essential role in the educational process, providing students with tools to acquire knowledge effectively and autonomously. However, the effectiveness of these strategies depends on psychological and motivational factors, and educators play a crucial role in encouraging the development of these skills, promoting self-regulation and critical thinking. Therefore, mastering these strategies empowers students to become successful, autonomous learners throughout their lives.

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Comparison of LSTM and Wavelet Transform-LSTM Models for Temperature Prediction in a part of Congo Basin

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***Abstract*—** *Currently, the Congo Basin represents the most important center in terms of biodiversity concentration, especially with the increasing deforestation observed in the Amazon. The available climate models are mostly at larger scales, and few of them focus on specific areas of the Congo Basin, such as the locality of Makokou in Gabon. A new approach is therefore needed to predict temperatures changes in this particular region. Although some work focus on temperature prediction, most do not use deep learning algorithms. This contribution aims to compare the predictions of a Long Short-Term Memory (LSTM) model with those from the combination of Wavelet Transform and LSTM (WT-LSTM). The developed LSTM model includes two LSTM layers, two Dropout layers (with a rate of 50 %) and a Dense layer to outpout the predicted value. The WT-LSTM model shows superior results compared to the LSTM model, with a root mean square error of 0.45 °C, a mean absolute error of 0.35 °C, and a Spearman correlation coefficient of 0.97 °C. These results highlight the importance of using advanced approaches to improve climate forecasts in areas crucial for biodiversity conservation. The increased accuracy of predictions could help better anticipate and mitigate the impacts of of local climate change, thereby contributing to the sustainable management of this ecologically sensitive region.*

I. INTRODUCTION

A major challenge of the 21st century, climate change poses a real threat (Belle et al. 2016) to the flora, fauna and the daily lives of the populations in the Congo Basin (CB) (Dellink et al. 2017; Adamo et al. 2018; Grooten and Almond 2018). In practice, climate variations inhibit the reproduction of certain plant species (Chakanyuka 2019; Bush et al. 2020). Animals are increasingly moving in search of water sources and food de points (Moukodouma et al. 2023). The survival of populations is threatened by frequent floods, landslides, sometimes even earthquakes (Adamo et al. 2018; Chirwa and Adeyemi 2020; Moukodouma et al. 2023). In addition to the aforementioned impacts, soil drought is becoming more prevalent in the region (Chirwa and Adeyemi 2020). With no arable land left, many inhabitants, of the Congo Basin

are gradually dying of hunger (Chirwa and Adeyemi 2020; Toto 2023).

The impact of climate change on each species (plant, animal and human) are becoming increasingly visible. Temperature variations are a key criterion of climate change. The importance of predicting temperature evolution lies in the fact that it plays a fundamental role for all living beings. For example, some forest trees require a minimum temperature to trigger their flowering (Bush 2018; Ren et al. 2021). The human body also actually needs a certain temperature to maintain proper functioning (Vecellio et al. 2022; Vanos et al. 2023). These various observations highlight the importance of focusing on temperature variations today (Lee et al. 2023).

In this context, several models based on statistical approaches and machine learning are increasingly being used to predict temperature evolution (Piccolroaz et al. 2016; Cifuentes et al. 2020). Statistical models are commonly to extract patterns from data and to predict new observations (Piccolroaz et al. 2016). In a study conducted at three points along the Ouémé River in Benin, rainfall, average temperature, and evapotranspiration forecasts were made possible using an ARIMA (AutoRegressive Integrated Moving Average) model (Nounangnonhou and Fifatin 2016). In another **st**udy, future data were predicted based on previous meteorological data from the Aceh Besar province on the island of Sumatra, using the ETS (Error, Trend, Seasonal) univariate time series forecasting model (Jofipasi et al. 2018).

In addition to purely statistical models, the improvement in the predictive performance of machine learning has led to the emergence of many other models (Guillaume 2019; Zameer et al. 2023). In this regard, in a study, The Support Vector Machine (SVM) algorithm proved to be better at predicting global land-ocean temperatures compared to the artificial neural networks used (Abubakar et al. 2016). The SVM (Support Vector Machine) algorithm was developed by the author Vapnik (Vapnik 2013) and is used for both classification problems (where the target variable is qualitative) and regression problems (where the target variable is quantitative).

In another context, Artificial Neural Networks (ANN) have been used for predicting hourly air temperature (Li et al. 2020; Haque et al. 2021; Gong et al. 2022). These studies show that, at the regional scale, deep learning models provide much more accurate forecasts than traditional machine learning models (Abubakar et al. 2016).

All these methods provide fairly acceptable results, but they have a major drawback. Statistical models, for example, calculate the probability of a meteorological phenomenon occurring (Moazenzadeh et al. 2022). However, the mechanisms and factors affecting air temperature changes are highly complex and nonlinear, which increases the difficulty in capturing the dynamic temperature changes when predicting long time series (Hou et al. 2022). Artificial Neural Networks are a powerful tool, but they do not always manage to retain the dynamics when the time series is very large (Bharadiya 2023).

Given the major drawback that characterizes each of the previously described methods, it appears useful to migrate towards the approach of recurrent neural networks with Long Short-Term Memory (LSTM). This approach has already demonstrated remarkable results in processing long time series (Yadav et al. 2020; Karevan and Suykens 2020; Hu et al. 2020).

The issue related to the study of temperature variations affect many countries, including those in Congo Basin (CB), of which Gabon is a part. The LSTM approach could be viable option for predicting temperature changes in this region. Indeed, LSTM has the advantage of better adapting to sequential data (Xia et al. 2020; Kang et al. 2020). In a study conducted at the meteorological station in Yinchuan (China), a model based on the bidirectional LSTM algorithm has able to predict hourly air temperature with a mean absolute error of 1,02 °C(Hou et al. 2022). Other work highlighted an LSTM model for predicting both temperature and humidity levels in buildings (Wang et al. 2021). A recent study conducted in Australia revealed an average p-value of 0,9994 for the chi-squared test, thus proving that the LSTM model designed in this case predicted future temperatures in Australia with very high accuracy for one year (Qiu 2023). In the Amazon, an LSTM network has been proposed to forecast minimum, average, and maximum temperatures until 2030 in 20 major cities traversed by the forest (Dominguez et al. 2023). In another study, also in the Amazon, a neural network architecture was developed to learn to detect deforestation end-to-end from time series(Karaman et al. 2023). Regarding our target region, climate studies based on Artificial Intelligence (AI) methods are virtually non-existent. A review reported some figures regarding AI publications in Africa. To date, out of 2468 published articles in AI in Africa, Cameroon has a representation percentage of 0.85% , followed by the Democratic Republic of The Congo (DRC) at 0.45% , and Gabon at 0.16 % (Ezugwu et al. 2023). However, in Morocco, a study based on LSTM algorithm was able to predict solar radiation (Boutahir et al. 2022). In Kenya, a country with similar characteristics very similar to those of our study region, a recurrent LSTM neural network model was able to accurately forecast monthly precipitation totals (Beunk 2021).

Unlike the Amazon, where a significant number of studies on temperatures variations prevail, the issue of temperature modeling remains very understudied in the Congo Basin region.

This work compares two models for predicting temperatures in Makokou, Gabon. The first model uses the LSTM architecture alone, while the second combines Wavelet Transform with the LSTM architecture. The objective is to demonstrate how integrating the trend obtained through Wavelet Transform improves the accuracy of temperature forecasts compared to the LSTM-only model.

This contribution is essential in a region that has long been forgotten, yet remains the largest carbon sink in the world today (Atyi et al. 2022). Governments and actors of the Conference of The Parties (COP) and the Intergovernmental Panel on Climate Change (IPCC) aim to keep the rise in global temperature within the 1.5°C threshold (MAIDOU 2020; Beaudoin and Chaloux 2023; Torre-Schaub 2023). This study could thus help the governments of the Congo Basin (CB) better plan their environmental policies to meet this objective.

Our contribution is organized as follows: Section II, Materials and Methods, presents the study area and the methodology followed. Section III, Results, highlights the main findings of the study. Section IV, Discussion, elaborates on the various results in light of the bibliographical references. Section V is the Conclusion, which allows us to summarize the study and outline future work that could further enrich the current research.

II. MATERIALS AND METHODS

1. Study area

The study takes place in the locality of Makokou, the capital of the Ogooué-Ivindo province in northeastern Gabon (Figure 1). Gabon occupies the largest portion of the Congo Basin forest (Balada 2021). This forest is predominantly found in The Ogooué-Ivindo region, particularly in the Ipassa-Makokou Biosphere Reserve and the Ivindo National Park (Roland et al. 2016). These two reserves alone host a diverse range of plant and animal species (Roland et al. 2016; Laguardia et al. 2021). Among them, there are approximately 18 species of mammals, 424 species of birds, 65 species of reptiles, and 47 species of amphibians (Roland et al. 2016). Additionnaly, the elephant, the forest's ecological engineer is present in large numbers in the Ogooué-Ivindo province (Berzaghi et al. 2019; Laguardia et al. 2021; Kermabon 2022). Like the rest of the country, the locality of Makokou has an equatorial climate characterized by alternating dry and rainy seasons (Roland et al. 2016). The average temperature in Makokou hovers around 24°C, and the annual average rainfall ranges between 1600 mm and 1800 mm (Roland et al. 2016).

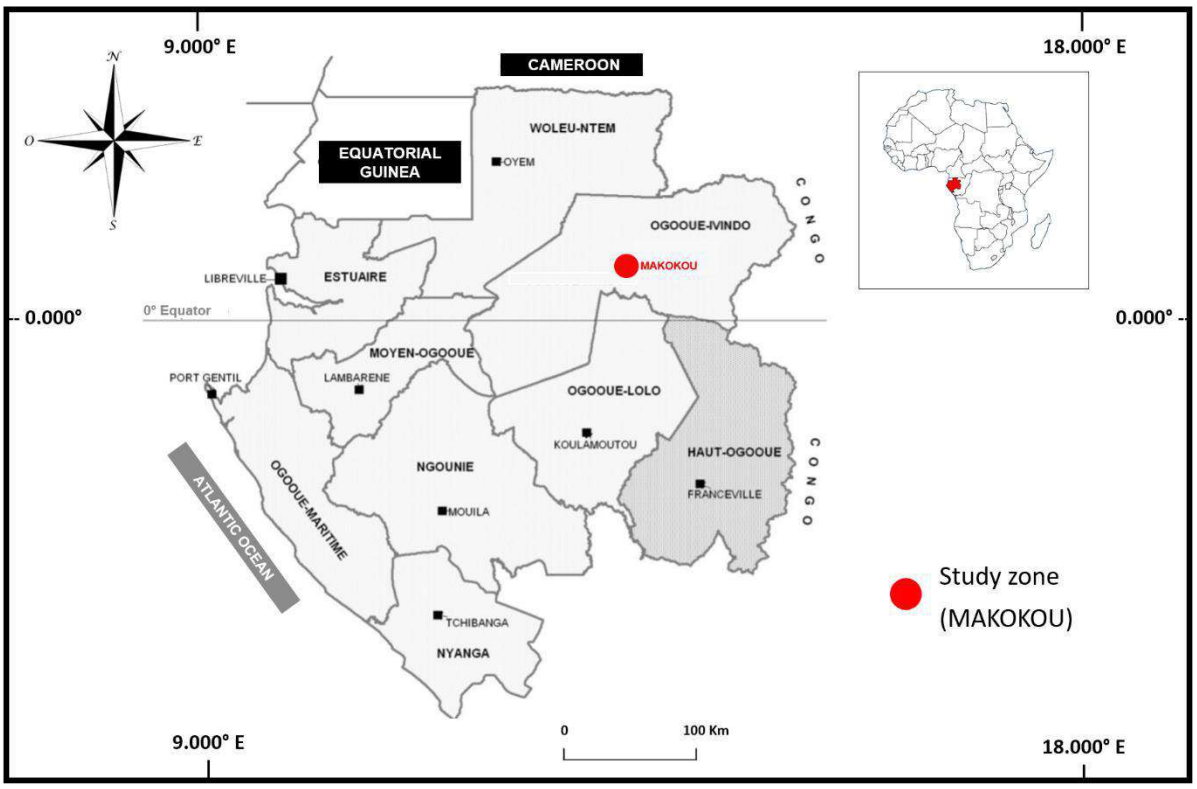

Fig.1: Location of study area

Thus, the locality of Makokou stands out as an area with a high concentration of biodiversity. This significant biodiversity warrants attention, considering the multiples roles it could play for human survival, as well as for the fauna and flora. It could also be a key driver in the fight against climate change.

2. Description of the Database

The climatic data for our study are from the locality of Makokou for the period 2000-2020. They were collected by the National Climatic Data Center (NCDC). The NCDC is a major global repository of meteorological data (Gad and Hosahalli 2022).Regarding our study area, only the period 2000 to 2020 was recorded, with a significant number of daily observations (approximately 4,695 observations were counted).

As illustrated in Tables 1a and 1b, many climatic parameters are measured at this station. The database contains the date of the day (YEARMODA), the average temperature (TEMP) in degrees Fahrenheit, the average dew point in degrees Fahrenheit (DEWP), the average sea-level pressure in millibars (SLP), the station's average pressure for the daily in millibars (STP), the visibility (distance to which objects can be clearly seen in meters) (VISIB), maximum temperature in degrees Fahrenheit (MAX), mimimum temperature in degrees Fahrenheit (MIN), total precipitation in inches (PRCP), and all weather conditions (FRSHTT). Specifically, in the acronym FRSHTT, we find Fog, Rain, Snow, Hail, Thunder, and Tornado.

Table 1a : Characteristics for the first 5 rows for the first 5 variables [source : NCDC]

YEARMODA	TEMP	DEWP	SLP	STP	VISIB
01/01/2000	70.5	69.2	1006.9	950.2	6.2
02/01/2000	74.1	68.7	1006.9	949.9	4.7
03/01/2000	74.6	70.6	1006.2	949.2	6.5
04/01/2000	74.8	70.7	1005.8	949.4	7.4
05/01/2000	74.2	70.8	1005.2	948.8	5

Table 1b : Characteristics for the first 5 rows for the other variables [source : NCDC]

YEARMODA	MAX	MIN	PRCP	FRSHTT
01/01/2000	75.2	68.4	0.39E	10
02/01/2000	84.9	65.5	0.03G	100000
03/01/2000	84.6	66.9	0.00G	100000
04/01/2000	84.6	67.1	0.00D	100000
05/01/2000	80.6	68.4	0.02E	100010

During our study, the available database was divided into two parts: one part was used for training future mordels (which accounted for 80 % of the data), and the remaining 20 % of the data was used to testing the neural network models developed in this study.

III. METHODS

3.1 Discrete Wavelet Transform (DWT)

The Discrete Wavelet Transform (DWT) is a discretized version of the Continuous Wavelet Transform (CWT), where the signal analyzed at specific scales and positions (Alessio 2016; Guo et al. 2018). Unlike the CWT, The DWT does not produce redundancy, making it more efficient for data storage and processing (Ponni alias Sathya and Ramakrishnan 2020; Chen et al. 2021).

In our study, we opted for Symlets of order 4 (Sym4). Unlike Daubechies wavelets, which have a non-symmetric support, Symlets are nearly symmetric. This symmetry makes these wavelets more suitable for certain applications, such as image processing and denoising, where edge effects are less tolerable (Shahbaztabar et al. 2018 ; Isabona and Kehinde 2019 ; Arfaoui et al. 2021). Additionally, like Daubechies, Symlets are orthogonal wavelets (Guo et al. 2022; Daud and Sudirman 2022). This property allows for decomposition and reconstruction without loss of information, which is essential for many signal processing applications (Kumar and Satyanarayana 2022). Finally, Symlets are effective for smoothing a signal, meaning they

can eliminate small irregularities while preserving larger trends (Gossler et al. 2023).

Before passing the temperature data to the LSTM neural network model, we applied a Discrete Wavelet Transform to the time series of average temperatures from the locality of Makokou. We then extracted the last component from the wavelet decomposition. This last component represents the trend, typically observed in the low frequencies. The extracted trend from the signal was saved in the database to be useful for the development of the models.

3.2 Development of Neural Networks Models

3.2.1 Long Short-Term Memory Model

Long Short-Term Memory (LSTM) is a type of recurrent neural network designed to overcome some limitations of traditional recurrent neural networks. The limitations of these traditional recurrent neural networks are related to learning long-term dependencies in data sequences. LSTM indeed has the advantage of being better suited for sequential data (Xia et al. 2020 ; Bagastio et al. 2023).

An LSTM network consists of a series of LSTM cells (or blocks). Each of these cells has a complex internal structure that allows it to retain, forget, or modify information based on the input data sequence (Qiu 2023).

The following Figure 2 presents the general architecture of an LSTM network.

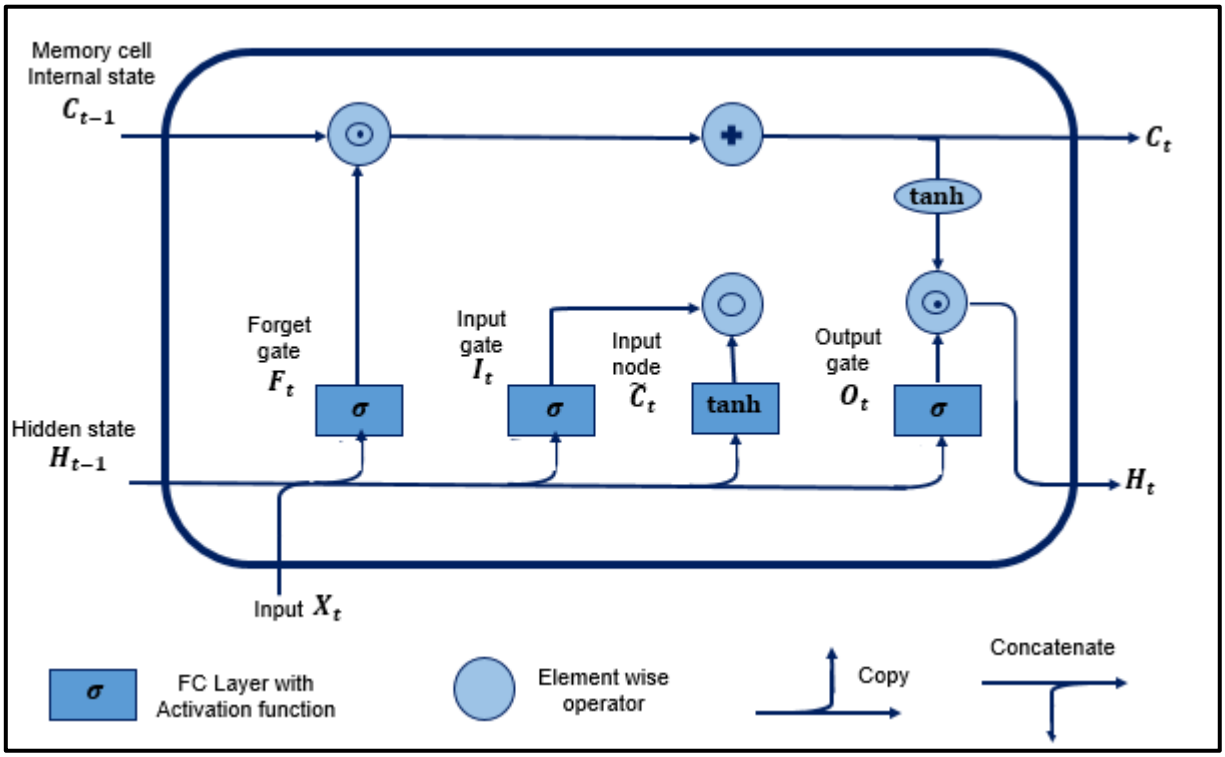

Fig.2: Architecture of LSTM Network [source: internet]

In the context of our study, we developed a five-layer LSTM model. This model consisted of two LSTM layers, two Dropout layers, and one Dense layer. In practice, the two LSTM layers (each with 50 units) function as memory blocks than can retain long-term information. To prevent overfitting, we added two Dropout layers with a rate of 50 %, meaning that 50 % of the neurons were randomly disabled during each iteration in the developed LSTM model. This regularization technique aimed to prevent the network from becoming too dependent on specific neurons during training.

Once the model was constructed, it was compiled using the Adam optimizer and the ‘’Mean_Squared_Error” loss function. Compilation is necessary as it configures the model for learning while clearly specifying how it should be trained.

Immediately after compiling the model, we trained it using the training dataset (80 % of the data). We then used our model to make predictions on the test data. Afterward, we reversed normalization process to bring the predicted values back to their original scale. Finally, we visually compared these predictions with the actual values to evaluate their correspondence.

The last step of our modeling involves interpretability. At this stage, we aim to assess the contribution of each explanatory variable to the model. To achieve this, we used Shapley values, which provide a consistent and fair method

for quantifying the impact of each explanatory variable on the model's prediction (Denis and Varenne 2022).

3.2.2 Performance Evaluation Criteria for the Models

3.2.2.1 Traditional Metrics

The models were primarily evaluated using three traditional metrics : Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE) (Boutahir et al. 2022; Ezugwu et al. 2023).

The RMSE is defined by the following equation (1):

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(Y_i - y_i)^2} \qquad (1)$$

In this formula, N represents the number, of observations, Y_i is the actual value, and y_i is the predicted value.

The Mean Absolute Error (MAE) defined by equation (2), is the average of the absolute differences between the prediction y_i and the actual value Y_i over a sample of N observations.

$$MAE = \frac{1}{N}\sum_{i=1}^{N}(|Y_i - y_i|) \qquad (2)$$

Starting from equation (2), we can assert that the smaller the MAE, the better the model in relation to the data.

The Mean Absolute Percentage Error (MAPE) is a statistical indicator used to measure the accuracy of a forecasting model. It represents the average error between actual values and predicted values, expressed as a percentage. More specifically, MAPE calculates the average of the absolute percentage errors of the actual values, allowing us to understand how closely or distantly a model's predictions align with the observed values. The formula for MAPE is as follows :

$$MAPE = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{Y_i - y_i}{y_i}\right| \times 100 \qquad (3)$$

Where N represents the number of observations, Y_i is the actual value, and y_i is the predicted value.

If the MAPE is low, it indicates that the model is accurate (the predictions are close to the actual values). Conversely, if the MAPE is high, it suggests that there is a significant discrepancy between the model's predictions and the actual values.

3.2.2.2 Wilcoxon Signed-Rank Test

The Wilcoxon Signed-Rank Test is used to compare paired samples, such as the actual values and the predictions of a model. The null hypothesis of this test states that the medians of the differences between the pairs are equal to zero. The alternative hypothesis states that the medians of the differences between the pairs are not equal to zero.

The Wilcoxon Signed-rank Test first calculates the differences for each pair of paired values. It then assigns absolute ranks to the differences by ordering them from smallest to largest. After that, the ranks of the differences are reassigned based on their original signs. Next, the test calculates the sum of the ranks for the positive differences and for the negative differences. Finally, the signed rank sums are used to compute the test statistic, which is compared to a reference distribution to determine significance.

Regarding interpretation, if the test statistic is large or small and the p-value is above the significance threshold (0.05), we do not reject the null hypothesis. However, if the previous conditions are not met, the null hypothesis is rejected.

3.2.2.3 Spearman's Rank Correlation Coefficient

Spearman's Rank Correlation Coefficient is a statistical measure that evaluates the strength and direction of a monotonic relationship between two variables (Astivia and Zumbo 2017). It is based on three key principles : monotonic relationship, ranks, and its formula (Al-Hameed and Khawla 2022).

A relationship is considered monotonic if, as the values of one variable increase, the values of the other variable consistently either increase or decrease, though not necessarily in a linear manner.

Instead of directly comparing the raw values of the variables, Spearman relies on ranks. The values of the variables are first ranked, and then the differences between these ranks are used to calculate the correlation. Since it is based on ranks rather than raw values, Spearman's method is less sensitive to outliers.

The Spearman rank correlation coefficient (ρ) is calculated from the difference in ranks between the two variables, following the formula provided in equation (5) (Eltehiwy and Abdul-Motaal 2023)

$$\rho = 1 - \frac{6\sum {d_i}^2}{n(n^2 - 1)} \qquad (5)$$

Where d_i is the difference between the ranks of each pair of variables and n being the number of data pairs.

If $\rho = 1$, the relationship is perfectly monotonic and increasing, and if $\rho = -1$, the relationship is perfectly monotonic and decreasing. In the case where ρ is zero, there is no monotonic relationship between the variables.

3.2.2.4 Test de Mann-Whitney U

To further strengthen the model results, we used the Mann-Whitney U Test to compare the median residuals of different models to see if there is a significant difference between their distributions (Vengatesan et al. 2018; Vierra et al. 2023).

The null hypothesis (H_0) of this test states that there is no significant difference between the two samples. In other words, the samples have similar distributions. Conversely, the alternative hypothesis (H_1) states that there is a significant difference between the distributions, meaning that one of the models tends to produce larger or smaller values than the other.

The Mann-Whitney U Test begins with ranking the data. The data from both samples are first combined and ordered from smallest to largest. Then, ranks are assigned to the values. If two or more values are identical, they receive the average of the ranks they would occupy if they were distinct.

After determining the ranks of the data, the calculation of the U statistics follows. For each sample, The Mann-Whitney U Test calculates a U score based on the sum of the ranks. The basic formulas are given in equations (3) et (4) (Wall Emerson 2023)

$$U_1 = R_1 - \frac{n_1(n_1+1)}{2} \quad (3)$$

$$U_2 = R_2 - \frac{n_2(n_2+1)}{2} \quad (4)$$

Where R_1 and R_2 representing the sums of ranks for samples 1 and 2, respectively, and n_1 and n_2 representing the sizes of samples 1 and 2.

The third step of the test is the selection of the U statistic. In practice, the smaller of the two U values is used to interpret the test.

Finally, the associated p-value is calculated from the U statistic to determine if the observed difference between the samples is significant. If the p-value is less than a threshold (often set at 0.05), we reject the null hypothesis in favor of the alternative hypothesis.

IV. RESULTS

1. Data exploration

The exploration of the database reveals that the daily average temperatures in the locality of Makokou fluctuate between 20 °C and 32 °C during the study period (2000-2020) (Figure 3).

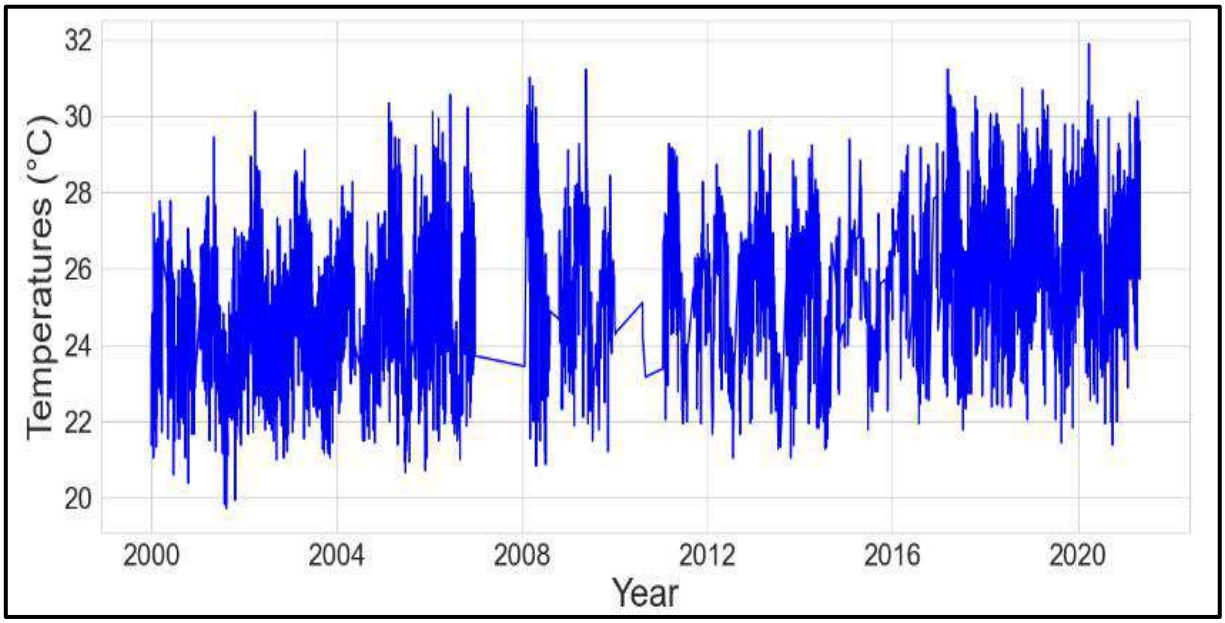

Fig.3: Evolution of Temperature Time Serie

As illustrated in Figure 3, the trend extracted after applying the Discrete Wavelet Transform shows a similar evolution to the raw data.

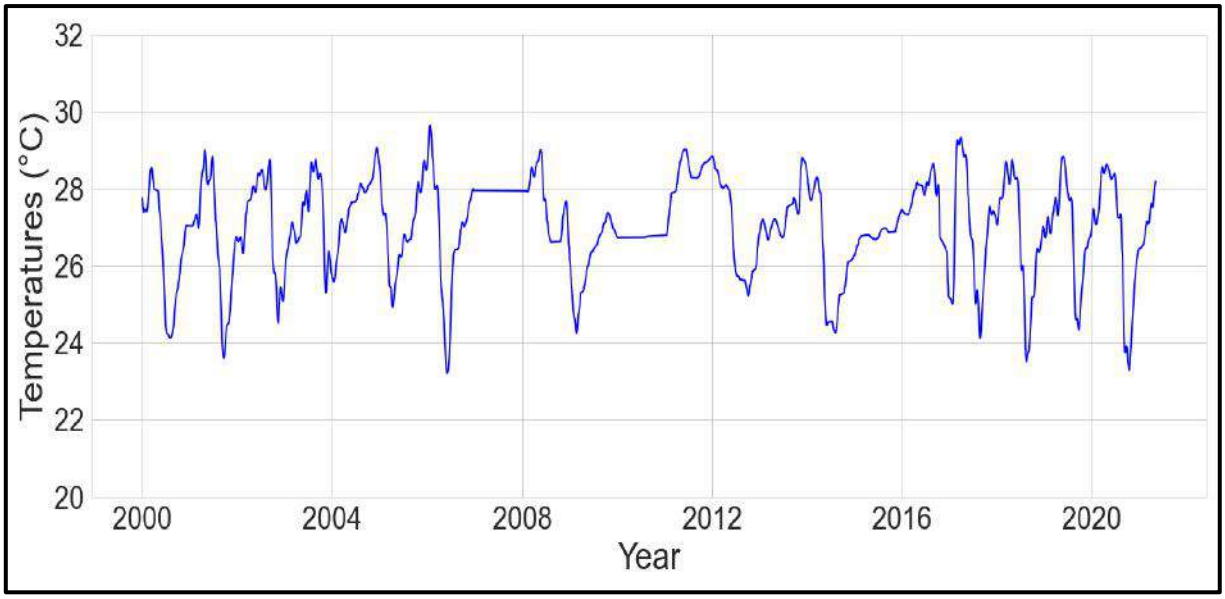

Fig.4: Temperature Trends

The similarity with the raw data suggests that the trend is relevant for modeling temperatures in the locality of Makokou.

2. Neural Network Models and Results

2.1 Long Short-Term Memory Model (LSTM) and Performance Evaluation.

Once the LSTM model was designed, we trained it (figure 5) and then tested it with the test data (figure 6). The following Figure 5 shows how the training and validation losses evolve during the model's learning phase.

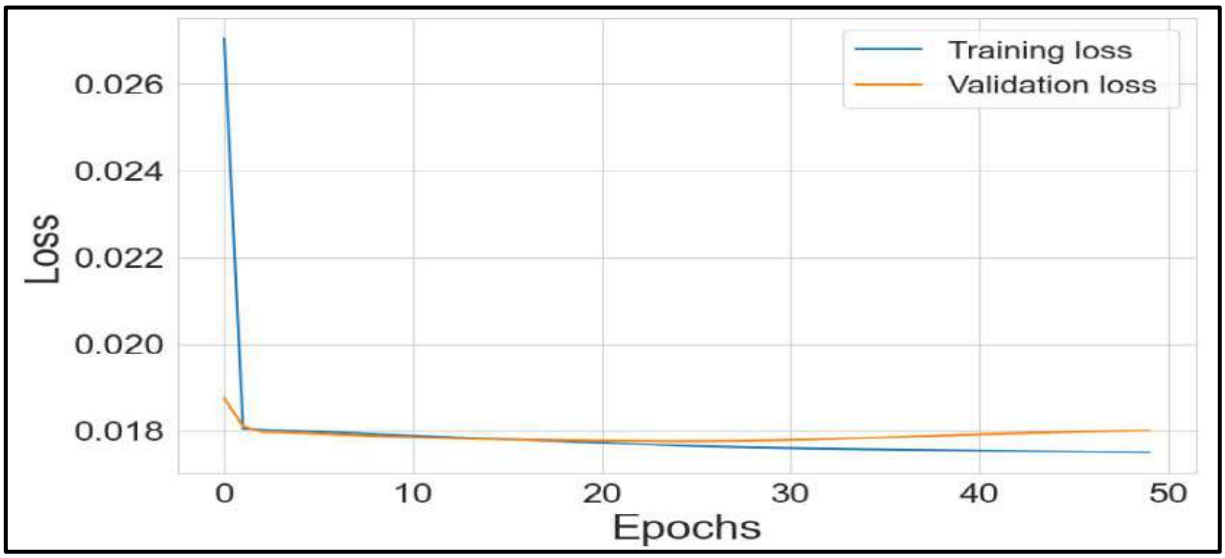

Fig.5: Training and validation loss curves of the LSTM model

Predictions were then made after training the model. Figure 6 highlights the results obtained.

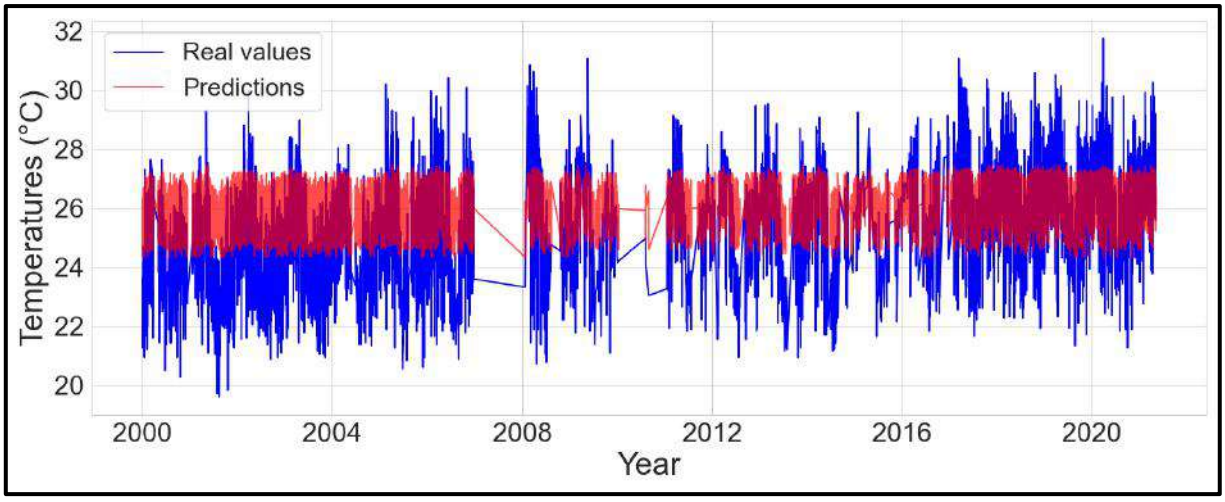

Fig.6: Actual values and LSTM Model Predictions

The observation of Figure 6 reveals that the simple LSTM model, which had not undergone any prior transformation, does not predict temperatures satisfactorily. The traditional evaluation metrics yielded a value of 1.62 °C for the root mean square error, 1.30 °C for the mean absolute error, and a mean absolute percentage error of 4.89 %.

To further evaluate the simple LSTM model, we conducted non-parametric Wilcoxon signed-rank test and the Spearman correlation coefficient. The Wilcoxon signed-rank test indicates a significant difference between the actual values and the predicted values (Table 2)

Table 2: Wilcoxon signed-rank test Results

	Wilcoxon signed-rank	
	Statistic of Test Z	**p-value**
LSTM	137748	1.12×10^{-21}

The Spearman correlation coefficient (Table 3) suggests a moderate significant correlation between the original values and the model's predictions.

Table 3: Spearman Correlation Coefficient Test Results

	Spearman's rank correlation	
	Correlation coefficient ρ	**p-value**
LSTM	0.40	8.25×10^{-34}

The hyperparameters of the developed LSTM neural network are listed in Table 4. These hyperparameters are parameters that we intuitively selected before training the model, with the aim of minimizing the evaluation metrics.

Table 4: LSTM Model hyperparameters

Parameters	**Values**
Number of Units LSTM	50
Epochs	50
Batch_size	32
Optimizer	Adam
Learning rate	0.001
Dropout rate	0.5

2.2 Wavelet Transform (WT) combined with Long Short-Term Memory Model (LSTM))

In order to improve the performance our previously designed LSTM Model, we replaced the raw data (average temperatures) with the trend extracted from the Wavelet Transform. Then, the model was trained for 50 epochs. Figure 7 illustrates the evolution of the training and validation losses.

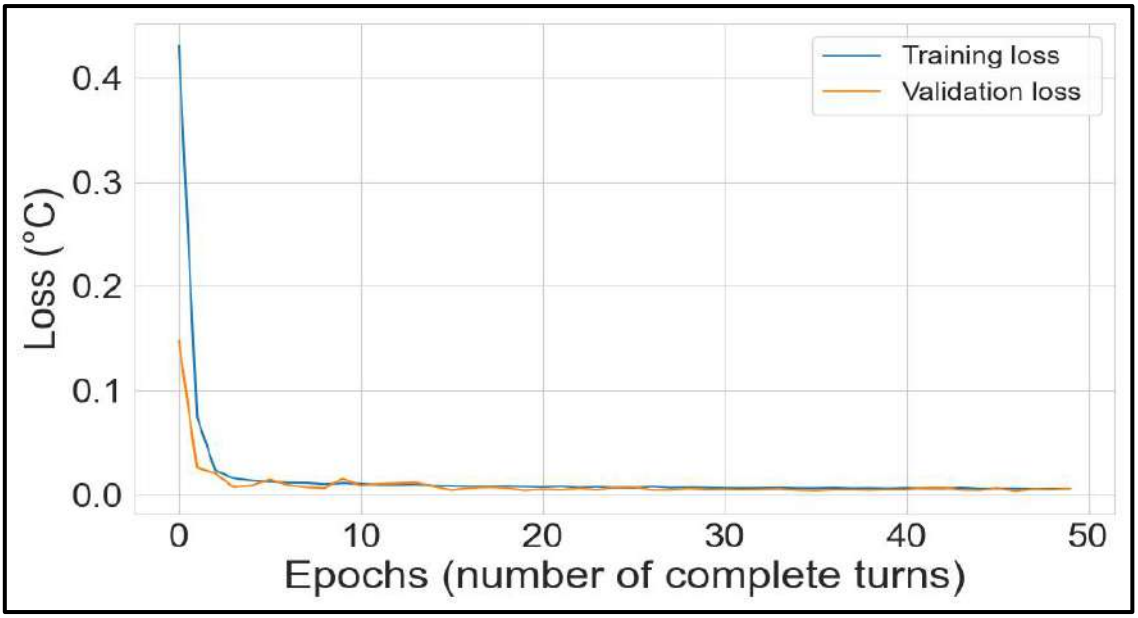

Fig.7: Evolution of the training and validation loss curves during the training process

There appears to be an overlap of the training and validation loss curves during the training process (Figure 7). Figure 8 highlights the predictions obtained from this new LSTM model. We observe that this time, there is an almost perfect match between the original data and the predictions.

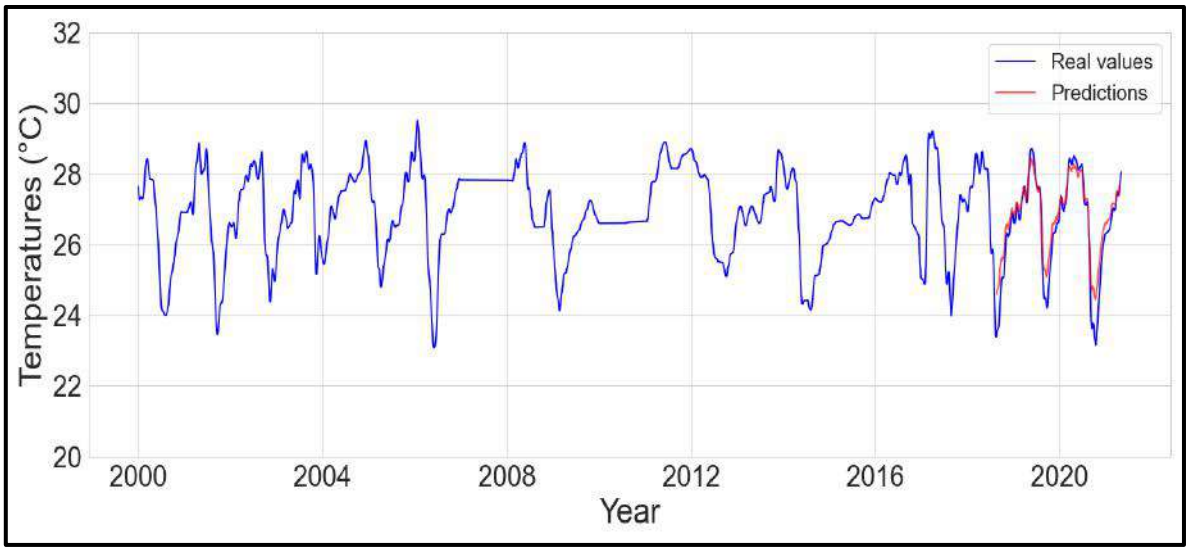

Fig.8: Actual values and Predictions of the WT-LSTM Model

The Root Mean Squared Error (RMSE), Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE) are 0.45 °C, 0.35 °C and 1.35 %, respectively.

The Wilcoxon Signed-Rank Test indicates that there is no significant difference between the real values and the predicted values (Table 5), which seems to confirm that the predicted values closely match the original values.

Table 5: Wilcoxon signed-rank Test Results

	Wilcoxon signed-rank	
	Statistic of Test *Z*	**P-value**
WT-LSTM	126748	0.08

The Spearman Correlation Coefficient (Table 6) suggests a strong and significant correlation between the original values and the model's predictions.

Table 6: Spearman Correlation Coefficient Test Results

	Spearman's rank correlation	
	Correlation coefficient ρ	**P-value**
WT-LSTM	0.97	0

The Mann-Whitney U Test reveals a significant difference between the residuals of the simple LSTM model and the WT-LSTM (Table 7)

Table 7: Mann-Whitney U Test Results

	Mann-Whitney U Test	
	Statistic U	**p-value**
WT-LSTM	3255419	9.71×10^{-75}

Finally, we evaluated the contributions of each explanatory variable to the output of the WT-LSTM model using Shapley indices (Figure 9). This calculation shows that the average dew point (DEWP), the mean sea level pressure (SLP), and the mean station pressure for the day (STP) strongly influence the model's output

This suggests that these variables play a crucial role in the predictions. Following these top three variables, other variables include visibility (VISIB), maximum temperatures (MAX), and minimum temperatures (MIN), which have nearly equal contributions (0.018). Lastly, we find total precipitation (PRCP) and the variable FRSHTT, which summarizes weather conditions.

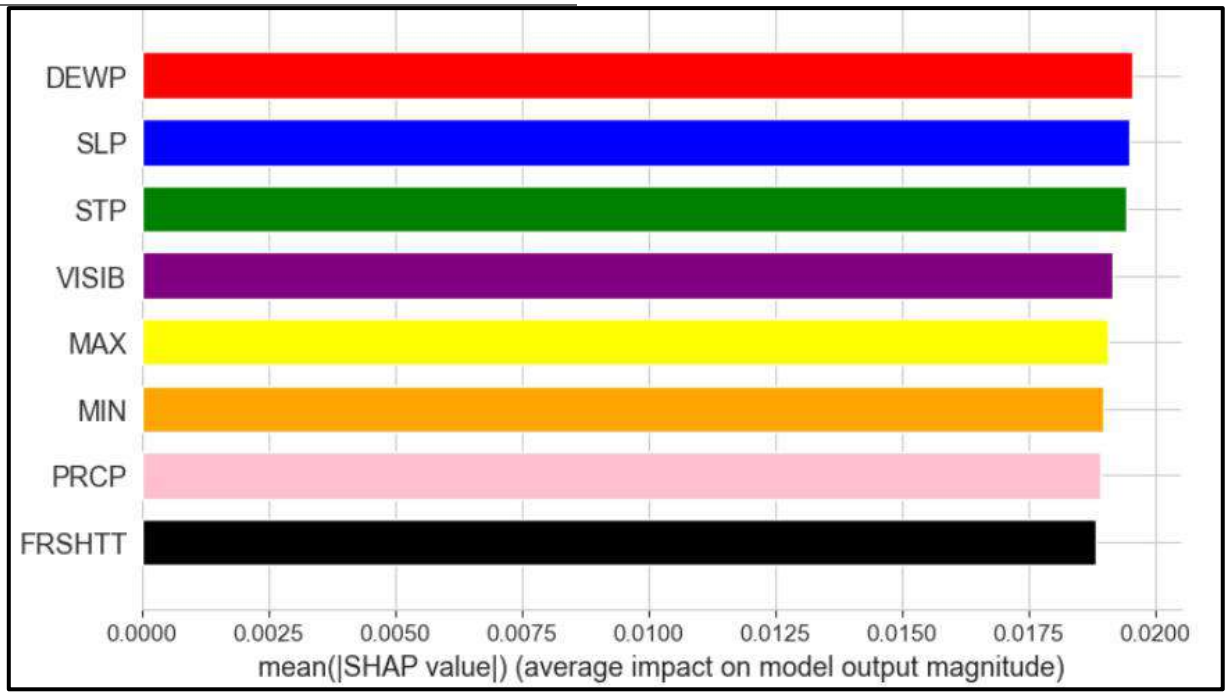

Fig.9: Contributions of explanatory variables to the WT-LSTM Model

V. DISCUSSION

For the 10th epoch during the training phase of our simple LSTM model, model convergence seems to appear. However, for the WT-LSTM model, convergence is observed earlier (around the third epoch) and is noticeable throughout the training, with training and validation losses oscillating around zero. This very rapid convergence of the WT-LSTM model could be explained by the presence of training data that is quite representative of the overall dataset and effective hyperparameter choices for the models. Indeed, the evaluation metrics RMSE, MAE and MAPE are respectively 0.45 °C, 0.35 °C et 1.35 %. Such values for our performance indicators suggest that the gap between predictions and actual values is minimal. These results seem to align with those obtained in a study by Park et al (Park et al. 2019). In this study, an LSTM model was also designed to predict temperature over short periods (6, 12 and 24 hours) and then extended to 7 and 14 days. This LSTM model consisted of 4 LSTM layers and 384 neurons (or units). The RMSE obtained in that study was 0.79 °C for the 24-hour prediction, 2.84 °C for the 7-day prediction, and 3.06 °C for the 14-day prediction. Furthermore, our results appear to be consistent with those obtained in another study (Inik et al. 2022). This study analyzed a ground temperature dataset from 2013 to 2021 in Turkey using an LSTM model to predict the average temperature. In this analysis, the authors developed a hybrid LSTM-GRU model able of predicting the average ground temperature in

Bingöl (Turkey). The developed model had hyperparameters of a learning rate of 0.001, two layers (LSTM et GRU), each with 200 units, and a Dense layer for the final model ouput. The RMSE achieved was $1.25\ °C$. All the metric values obtained in these various studies are close to ours. Although not working on the same dataset in each case, this comparison with these different studies is still useful, as it addresses the same problem and utilizes the same LSTM strategy. We demonstrate in our work that with a low number of layers (2 LSTM layers) and neurons (50), our simple LSTM model yields less satisfactory predictions. However, after extracting the trend via a Wavelet Transform, The WT-LSTM model maintaining the same number of LSTM layers and units now predicts temperatures better, with minimal discrepancies between actual values and predicted values.

The Wilcoxon signed-rank test reveals a significant difference between the actual and predicted values for the simple LSTM model, with a p-value of 1.12×10^{-21}. In contrast, for the WT-LSTM model, the Wilcoxon signed-rank test suggests that there is no significant difference between the actual and predicted values. These results indicate that while the simple LSTM model may be effective in certain situations, it fails to capture specific fluctuations in the temperature time series in this case. On the other hand, the p-value (0.08) exceeding the significance threshold (0.05) in the latter case emphasizes that the combination of Wavelet Transform and LSTM is well suited to better capture the underlying complex relationships in temperature data. Integrating the Wavelet Transform into the LSTM structure significantly enhances its ability to capture multi-scale variations and fluctuations in time series.

Several studies confirm the effectiveness of integrating the Wavelet Transform into predictive models. In this regard, a recent study explores the combined use of Wavelet Transform and LSTM for weather data forecasting, showing that this combination allows for a significant improvement in prediction accuracy, particularly for non-stationary time series. The study demonstrated that the prediction of the distillation column temperature was improved by 10 % using the LSTM network when the data were pre-transformed via the Wavelet Transform (Kwon et al. 2022). Another article indicates that neural network models based on the Wavelet Transform achieved better performance in predicting climatic time series with improved capture of variations at different scales. This study specifically employed the combination of Wavelet Transform and LSTM to predict daily average temperature in the city of Mugla (Turkey). The study noted that with this combination, the model outperformed the standard LSTM, achieving a mean squared error of $0.56\ °C$ (Ghasemlounia et al. 2024).

The Spearman correlation coefficient is 0.40 for the LSTM model. Although this value is statistically significant with a p-value of 8.25×10^{-34}, which is less than 0.05, it indicates a moderate correlation coefficient between the predicted and actual values. This moderate correlation suggests that the simple LSTM model does not sufficiently capture the complex relationships present in the data. However, for the WT-LSTM model, the Spearman correlation coefficient reaches an impressive value of 0.97 with a p-value of zero, indicating an almost perfect correlation between the predicted and actual values. This confirms that the WT-LSTM model is effective in capturing and reproducing the trends in real data, thus providing accurate and reliable predictions.

In a complementary study (Vikas Goyal et al. 2022), the authors demonstrated that the Spearman correlation coefficient is a relevant performance criterion for evaluating temperature forecasting models, such as those using LSTM neural networks. They observed that the Spearman correlation coefficient was statistically significant across all evaluated models, reinforcing its usefulness in validating model performance.

Additionally, The Mann-Whitney U Test reveals a significant difference between the residuals of the simple LSTM and WT-LSTM models. This difference indicates that the two models are not equivalent in their ability to predict average temperature in the locality of Makokou. The results of the Mann-Whitney U Test, combined with the Spearman correlation coefficient, suggest that the WT-LSTM model may offer superior performance compared to the simple LSTM model. This tests thus support the notion that the WT-LSTM is not only more accurate in terms of prediction precision but also more robust in capturing the complexities of the data. In another study, models were developed to predict temperature in wind farms (Mishra et al. 2020). The comparison of these models showed that those based on Wavelet or Fourier Transforms exhibit better performance, demonstrating the added value these transforms bring to deep learning model predictions.

Shapley values reveal that the average dew point (DEWP), mean sea level pressure (SLP), and average station pressure for the day (STP) significantly influence the model's output. Indeed, the average dew point is an important indicator for predicting fog, rain, or snow formation, which directly influences temperature predictions via weather models. A study analyzed the relationships between air temperature and the average dew point in the United States (Russell 2024).The study demonstrates that the average dew point plays a key role in predicting temperatures and

precipitation, as it is closely related to air humidity. Specifically, the higher the average dew point, the more moisture the air contains, which directly affects the weather models used to predict temperatures. The authors conclude that considering the average dew point in prediction models improve forecast accuracy, particularly for extreme weather events such as heatwaves or heavy rainfall.

Moreover, mean sea level pressure and station pressure significantly influence large-scale weather phenomena such as temperatures. Indeed, atmospheric pressure affects temperature by influencing air density and its ability to retain heat. For instance, in a high-pressure area, air descends, which may lead to an increase in temperatures due to adiabatic compression. Conversely, in a low-pressure area, air rises, which can lead to a decrease in temperatures (Ning et al. 2018). In this regard, a study showed that deep learning predictive models (like LSTMs) typically exploit sea level pressure to forecast events such as storms, confirming the considerable contribution of sea level pressure in predicting climatic variables (Rus et al. 2023).

Although it has the lowest Shapley contribution, the variable FRSHTT, which summarizes the weather conditions of Fog, Rain, Snow, Hail, Thunder and Tornado, also influences the model's output. This rightly confirms the predominant role of weather conditions in temperature prediction. This is supported by recent studies (Cifuentes et al. 2020; Azari et al. 2022) that present a significant number of studies showing that various weather conditions, including total precipitation and maximum temperature, greatly influence global, regional, or even local temperatures predictions.

VI. CONCLUSION

The major objective of our study was to predict temperature in the locality of Makokou by utilizing a database of climate parameters covering the period from 2000 to 2020. In this context, two deep learning models were proposed: the first based on a classic LSTM architecture, and the second incorporating a Wavelet Transform (WT-LSTM) to capture underlying trends and variations in the time series.

Model validation relied on traditional metrics such as the Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE). Additionally, non-parametric tests, namely The Wilcoxon signed-rank test, The Spearman correlation coefficient, and the Mann-Whitney U test, were employed to reinforce the validation criteria for the models.

The results obtained showed an RMSE of 0.45°C for the WT-LSTMTO, compared to 1.62°C for the simple or standard LSTM model. These results indicate that the model based on the Wavelet Transform (WT-LSTM) effectively captures complex relationships in the meteorological data. The Wilcoxon signed-rank test revealed no significant differences between the predictions of the WT-LSTM model and the actual values. This conclusion is reinforced by the Spearman correlation coefficient, which reached a value of 0.97 for the WT-LSTM model. This value, significant correlation between the predictions of the WT-LSTM model and the actual values.

Moreover, the Mann-Whitney U test highlighted a significant difference between the residuals of the two models, demonstrating that the two architectures do not capture the underlying relationships in the data identically. This confirms that the WT-LSTM model, which incorporates the Wavelet Transform, is better suited to model complex climatic trends in temperature time series.

In conclusion, this study demonstrates that adding the Wavelet Transform to an LSTM architecture significantly enhances the predictive performance of recurrent neural networks, particularly in the context of long-term temperature forecasting. It would be interesting in future studies to explore the integration of this model with other advanced deep learning techniques and to apply this method to order climate parameters such as rainfall, in order to generalize these results and improve the understanding of meteorological dynamic in various regions of the Congo Basin.

CODE AVAILABILITY

The Python codes for all scripts used in this study are available upon request from the corresponding author.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest

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The Dark Web and Cybercrime: Identifying Threats and Anticipating Emerging Trends

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***Abstract*—** *Background/Objective: The Dark Web has played a pivotal role in the progress and sophistication of cybercrime. It provides an incubation network beyond the reach of traditional search engines where cybercriminals create and display exploit kits, offer illicit goods and services, and exchange confidential insider intelligence. Cybercriminals are highly adept at selecting targets, applying tools to achieve their objectives, and minimizing red tape. The increasing sophistication of cybercriminals and the exponential rise of cybercrime against critical infrastructure underlines the necessity of identifying emerging threats. This research aims to investigate the evolving threats within the Dark Web, including crimeware-as-a-service and the integration of AI/ML into cyberattacks to inform risk management strategies and strengthen security measures. Research Problem: The exponential rise in cybercrime against critical infrastructure reflects growing sophistication presenting a significant challenge to organizations and society. The motivation behind cybercrime is fundamentally driven by self-greed, which has contributed drastically to the magnitude of changes in methods used by cybercriminals to enhance profitability. The impact of cybercrime on business organizations presents an adverse effect on society and carries significant risks for the progress of individuals and the world. As cybercriminals adopt new technologies and services such as crimeware-as-a-service, identifying emerging trends becomes crucial to developing proactive strategies for detecting and preventing cyber threats. Methodology: This research employs a systematic literature review approach to analyze emerging trends in cybercrime originating from the Dark Web. The review includes scholarly articles, news sources, and blog posts from platforms like Google Scholar, IEEE Xplore, and various libraries. The key focus is to answer questions regarding the relationship between the Dark Web and Cybercrime, accelerating cybercrime activities, and the benefits and implications of these new trends. Results: Key findings of this paper range from the rise of crimeware-as-a-service attacks and the increasing use of AI and machine learning capabilities by cybercriminals to automate attacks across various businesses and organizations propounded along with information related to entry points and cybercrime attack pathways. The emergence of sophisticated cybercrime techniques, including ransomware-as-a-service, targeted AI attacks, and exploitation of IoT vulnerabilities, are critical trends. Social engineering, malware, and the rise of remote work have expanded the attack surface for*

cybercriminals. Discussion: As the use of cybercrime continues to metamorphose, the identification of new threats and extrapolation of emerging trends is critical to investigate the challenges associated with the monitoring and detection of illegitimate activities on the Dark Web as well as for the establishment of proactive risk management strategies and implementation of robust security measures. The research highlights the transformation of cybercrime into a structured and scalable ecosystem driven by technological advancements and service-based attack models. Cybercriminals now leverage AI/ML to increase the sophistication and success of their attacks. The commoditization of cybercrime has enabled less skilled individuals to participate amplifying the volume and diversity of threats faced by organizations. Conclusion: Organizations must remain vigilant and adaptable as cybercrime continues to evolve and adopt emerging technologies. The findings emphasize the need for proactive risk management, continuous monitoring of cybercrime trends, and robust security measures to mitigate the increasing threats originating from the Dark Web. Future research should focus on deeper exploration of AI-driven attacks and developing more advanced countermeasures to safeguard critical infrastructure.

I. INTRODUCTION

The Dark Web is like a hub for illicit activity. It also provides services like botnets and zero-day vulnerabilities for lease. An accumulation of amenities concealed from standard internet users and web crawlers is known as the "Dark Web." The primary data available on the Dark Web is stolen data, drugs, illegal goods, counterfeit money, weaponry, malware, hacking tools such as exploit and phishing kits, and illicit pornography but research has also exposed that there are many merchandise offerings related to cybersecurity including botnets that can be least, credentials for a variety of different organizations, and zero-day vulnerabilities. Inhabitance of the Dark Web includes nation states and cybercriminal organizations maturing and professionalizing their capabilities while bartering their stolen data and hacking services (Zhang & Zou, 2020).

The exact magnitude of the Dark Web is challenging to estimate as most web properties are temporal in nature due to law enforcement, internet service providers (ISPs), and tension with rivals as well as self-enforced detection avoidance by taking the sites offline on purpose. The growth of the Dark Web has been massive as in 2012 there were only a few hundred websites which exceeded 100,000 websites in 2020 (Cascavilla et al., 2021). Of note is that most of the websites on the Dark Web are isolated islands with no links to or from other websites. The Dark Web can only be accessed with distinct software bestowing entry to networks that conceals the identity of the users as well as the supplier of the services (Adewopo et al., 2020). The Dark Web is made up of web properties, marketplaces, message boards, and social media. Not only does the Dark Web provide anonymity, but it also conceals network activity and the information traded through it (Holt, 2012). Groups of hackers make use of the Dark Web systems to distribute hacking utilities, file sharing, malware, compromised data, ransomware, and attack plans to discuss their activities and disseminate current relevant knowledge. The offerings in the Dark Web have evolved into service offerings such as ransomware-as-a-service (RaaS), malware-as-a-service (MaaS), phishing-as-a-service (PaaS), Crimeware-as-a-service (CaaS) which demonstrates that cybercrime is transforming from a fad into a growing business empire.

The evolving service models have enabled anyone including lower-skilled criminals with Bitcoin to perform activities as a hacker (Samtani et al., 2020). The objective of the attack may not necessarily be direct monetary gain but the end goal may be to compromise the organization's infrastructure to steal information that in turn could be sold on the Dark Web. Currently, the business model is expanding to have professional branding and marketing promotions to make their products more appealing and increase their cash flow (Rudesill et al., 2015). The more affluent cybercriminals offer customer support assistance with their products to provide a differentiator so that they attain a competitive advantage in the congested virtual marketplace. Within the Dark Web, cybercriminals also recruit personnel similar to a contemporary organization by using job postings and interviews but they need to exert caution to ensure the potential employee is not a disguised law enforcement agent (Basheer & Alkhatib, 2021).

TOR (The Onion Router) and I2P (Invisible Internet Project) networks are two of the most highly favored networks that facilitate propagating content on the Dark Web (Świątkowska, 2020). TOR was implemented in 2004 after the deployment of the relay network. At that point, TOR began to not only offer online anonymity to applications over cyberspace but also allowed the deployment of anonymous services over the Internet. The TOR Browser was created to facilitate safe web surfing in an anonymous fashion (Sindelar & Ferguson, 2021). This browser transmits all web requests via the TOR network while cleansing all fingerprinting information from the transmitted data. The TOR browser fosters hidden services with hidden IP addresses to ensure anonymity between users and websites.

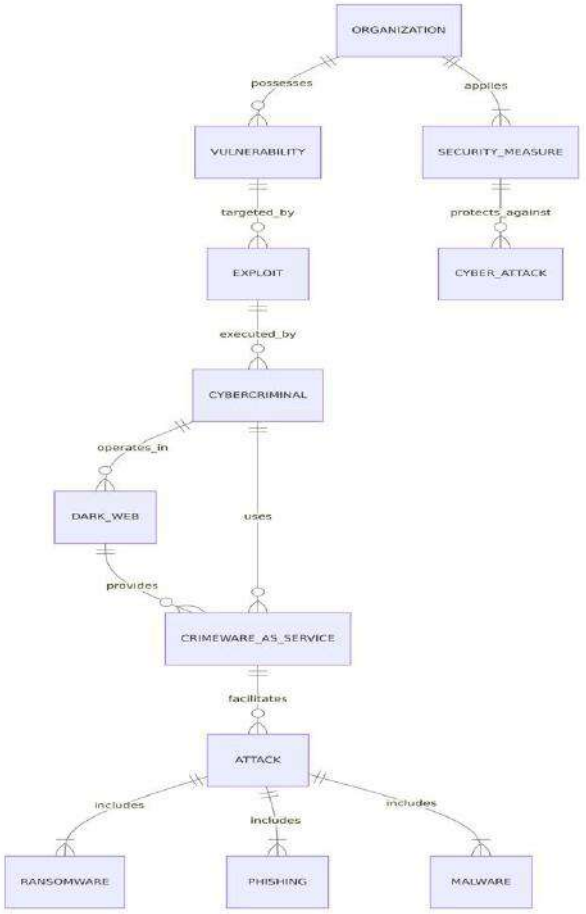

Fig.1a: The Interplay between Dark Web & Cybercrime

The Dark Web has expedited cybercrime's evolution into a versatile reputation aware business model by delivering an anonymous internet-accessible ecosystem that allows cybercriminals to cooperate, structure, increase their proficiencies, and form illegitimate business fronts. Criminal endeavors committed in a digital domain can be considered "cybercrime" (Weigand, 2023). The primary goal of cybercrime is to illicitly obtain as much as possible using the least amount of resources. Besides hacking, other varieties of crimes manifest into this realm. Initially, cybercrime was committed by hackers to achieve personal fame and increase their reputation and was not perceived as a source of income until the dotcom era in which the initial phase of cybercrime began from 1990 to 2006. The expansion of cybercrime has been enormous as reported between 2008 and 2021, there was a 207 percent growth in cybercrime activities resulting in damages reaching about $7 billion in 2021 which was being propelled by developing a cybercrime supply chain with enhanced professionalization and collaboration. Beginning in the 1980s, $6 trillion of destruction can be directly attributed to cybercrime and the amount of damages is expected to increase to $10.5 trillion by 2025 (Morgan, 2020). In 2020, 4.7 million cyber-attacks were declared in the United States in comparison to 1.5 million cyber-attacks in 2010 which is an approximate 300 percent increase in the total number of cyber-attacks (Carmiel, 2022).

The majority of victims originate from the healthcare, finance, government, education, and energy industries of G20 countries. As most people are reliant on groceries, apparel, and instruments supplied by firms connected to the Internet, any interruptions to these organizations' operations could interrupt the supply chain resulting in regular people not having day-to-day essentials (Glas, 2021). Monetary impact as a result of cybercrime can be colossal and extremely challenging to forecast or estimate. Similar to the advancement of genuine business, cybercrime is undergoing a similar growth period in which is experiencing progressive evolution to increase the return on investment. Cybercrime has been attacking organizations to increase payouts going back to 2018 as it continues to evolve its business strategy to a service-based paradigm. This has enabled cybercriminals to utilize multifaceted supply lines to facilitate attacks with plug-and-play elements (Boehm et al., 2022). The approach to cybercrime has transformed to be more methodical and focused. The cybercriminals are spending more time planning by concentrating on the selected target's architecture which will expand the effectiveness and multiply the monetary reward to increase their influence. The difficulty in securing critical information has been exacerbated due to the number of cyber-attacks that are occurring and the variety of cyber threats that are on the rise. For instance, RaaS has increased the number of ransomware attacks making this threat mainstream. As cybercriminals share their skills and expertise, the exploits are becoming increasingly more complex and detrimental (Ryan, 2023). The Dark Web with its developing environment enabling chats and online communities boosts reliable collaborations

and fine deception. Cybercrime can showcase that companies have violated consumer privacy regulations during successful exploitation. The flowchart diagrams (1a) and (1b) illustrate how cybercriminals infiltrate organizations using various attacks and services which lead to data theft, ransomware deployment, and monetary gain.

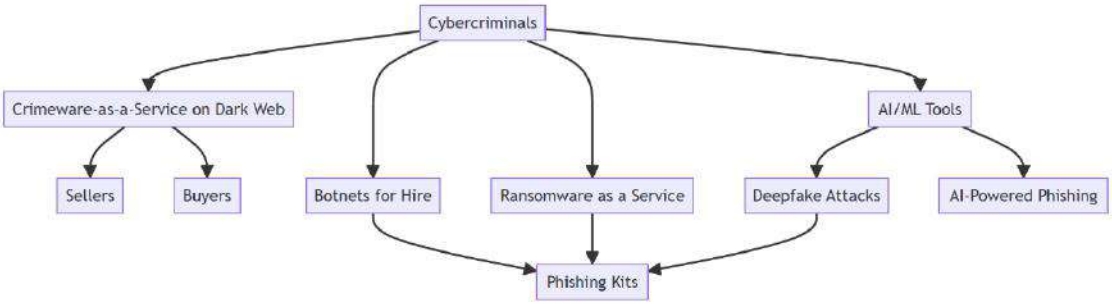

Fig.1a: Emerging Cybercrime Trends

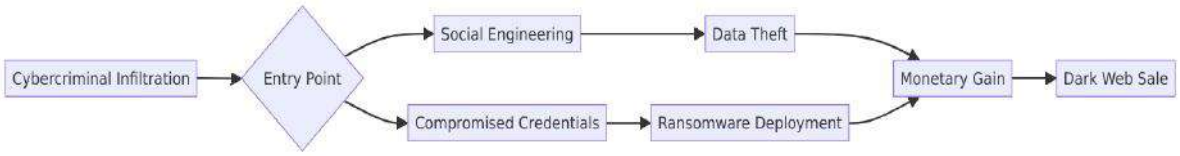

Fig.1b: Cybercrime Attack Pathways

There are four primary takeaways to understand regarding emerging cybercrime. One is that every attack needs an entry point into the target's infrastructure which renders control and access as primary requirements when executing cybercrime. One of the most common entry points heavily favored by cybercriminals currently is social engineering. Another entry point that is popular is the use of compromised credentials which can be obtained on the Dark Web at a minimal cost (Morgan, 2020). A third entry point can be through the exploitation of existing weaknesses and vulnerabilities within software and infrastructure. The second takeaway from cybercrime is the commoditization of exploit kits decreases costs and at the same time provides an income source for cybercriminals who can lease specialized software for exploitation in parallel with allowing the malicious software authors to provide training and intricate instructions with the details needed to successfully execute the malicious software (Labs, 2022). This demonstrated the maturation of the malware business model as cybercriminals are also transforming to bartering their knowledge and capabilities while no longer marketing their malicious utilities. It was identified by Wolf Security that the cost for 91 percent of marketed exploit kits was under $10, however, the pricing of tailored exploit kits varies from $1000 to $4000 (Security, 2022). The third takeaway is that in environments for cybercriminals, complex feedback tracking has been created so that suppliers and clients can track trustworthiness and client ratings. The final and fourth takeaway is that the cybercriminal communities in the Dark Web allow a place for collaboration between clients, suppliers, partners, and potential staff (Mador, 2022). Cybercrime will continue to evolve as new threats and trends emerge (Biedron, 2024).

II. LITERATURE REVIEW

The Dark Web is comprised of a combination of concealed services offering a range of illegal goods for sell from weapons and drugs to illegal pornography as well as cyber security related material including stolen credentials, zero-day exploits, and botnets that can be leased (Schäfer et al., 2019). The Dark Web's dimensions and actions are challenging to measure and map due to outside influence from service provider monitoring, law enforcement investigations, and competitor manipulation (Rawat et al., 2022). It is noted that that Dark Web requires specific software providing anonymity for both the client and service provider to enable access (Singh, 2024).

Criminal activities and content including hacking utilities, cyberattack plans, malware, ransomware, and compromised confidential information including credentials plans are considered to be primarily hosted in the Dark Web (Montasari & Hopcraft, 2024). Expansion can occur in cybercrime networks along with new paths for strategizing and executing cybercrime due to social network forums (Kaur et al., 2024). Access to the Dark Web

conceals the client's information as well as the data traversing the network while requiring custom software to facilitate access (Schäfer et al., 2019).

Cybercrime as a business is continuing to transform similarly to genuine organizations to enhance efficiencies by providing as-a-service offerings. This new angle for crime related business not only commoditizes malware providing an income stream to those threat actors with expertise but also provisions more advanced attacks to a broader spread of individuals who are not highly skilled for a reasonable cost (Townsend, 2022). Four trends are detailed including increasingly destructive attacks, more targeted attacks against the manufacturing sector conducted by nation-states, adoption of contemporary technologies such as AI by threat actors, and the continued improvements of efficiency in the cybercriminal environment to improve profitability.

Cybercrime is continuing to increase which is being powered by a cooperative clandestine supply structure that is evolving to be more professional and customized while supplying affordable and abundant tools and services (Security, 2022). Measurements of trust through a feedback and complaint notification methodology is being introduced in the world of cybercrime. The most prolific attack vector for malicious actors continues to be exploitation of unpatched vulnerabilities in widespread software (Malik et al., 2024). An accelerating number and variety of cyber-attacks are occurring which is increasing the challenge in providing adequate security to protect confidential data. Ransomware-as-a-service offerings originating from and marketed by associations of threat actors have led to an excessive number of ransomware incidents (Enterprise, 2022). The transformation of the business model regarding working from the office to working at home as a result of the COVID-19 lockdowns has resulted in growth of home Wi-Fi connectivity to business infrastructure and in turn, an increase cybercrime targeting personnel working from their home offices (Kelly, 2023). Several trends were outlined including the continued increase of COVID related threats, the proliferation of malware, the threats incurred with IoT technologies, the spread of ransomware related attacks, and the growing popularity of crypto jacking attacks.

Threats and mitigation techniques continue to develop in the sector of cybersecurity (Kaspersky, 2019). A list of trending cybersecurity topics were discussed including risks related to the remote working business methodology, cybercrime related to the continued proliferation and evolution of IoT related technologies, the increasing threat related to the continued proliferation of malware, threats related to the migration from organization owned data centers to cloud infrastructure, the continued improvement in effectiveness of social engineering related attacks, the growing exposure and number of compromises involving personally identifiable information (PII), the success of multi-factor authentication bypass techniques, concerns regarding cybercriminals making use of artificial intelligence in attack automation, and a variety of contemporary issues surrounding mobile security cybersecurity (Kaspersky, 2019; Top Cybersecurity Threats, 2023). Several contemporary cybersecurity trends that are continuing to evolve introducing risk to businesses, governments, and individuals in 2023 were discussed (Top Cybersecurity Threats, 2023). The proliferation of hybrid and remote work environments as well as smartphones were theorized as threats to personnel and companies. Several attack types including phishing, ransomware, crypto jacking, and other forms of social engineering were discussed as becoming more advanced while being spread more rapidly [36]. IoT devices and connected cars were recognized as increasing in risk and growing as a favorite target of hackers (Anzaruddin et al., 2024).

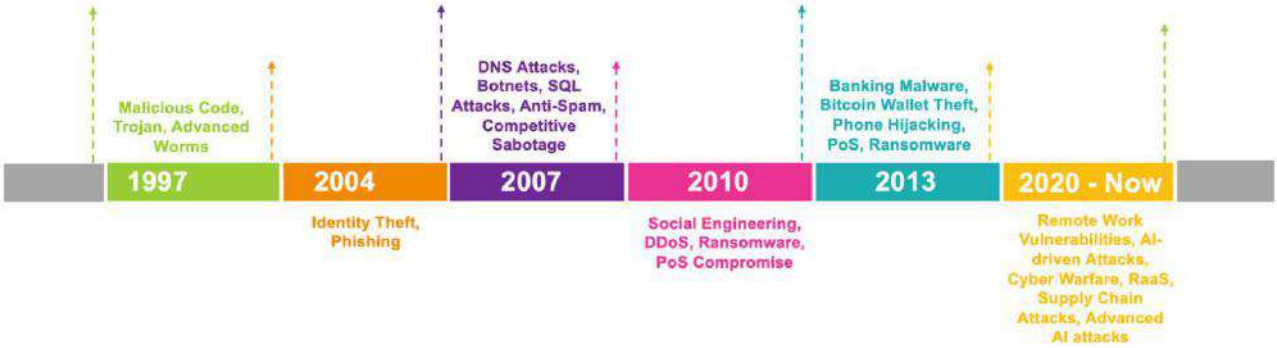

Fig.2: Evolution of Cybercrime Trends

Many trends agreed with other studies including the proliferation of ransomware, the usage of artificial intelligence in cyber-attacks, and the variety of criminal service offerings of crimeware-as-a-service. Satellite-based

internet networks were discussed as a target of interest for cybercriminals to have a conduit to conduct Internet based attacks and to have another venue to blend malicious activity with normal traffic (Fortinet, 2022). Money laundering-as-a-service with increased automation to reduce manual overhead as well as to provide concealment was also discussed. A concern was reasoned that threat actors are evolving to become more professional while creating business strategies to increase income streams (Micro, 2022). Many of the same trends including the increasing threat of social engineering and ransomware, goring threats to the work at home business model, and security gaps with organizations migrating from company owned data centers to the cloud were debated (Sahu et al., 2023). Former techniques were recognized as being subjected to modification to bypass current security controls as one of the techniques used by cybercriminals to evolve. Many matching trends from other studies were mentioned including proliferation of phishing and other social engineering attacks, increased ransomware and malware incidents, the integration of AI and IoT devices into cybercrime, continued spread of crypto jacking, continued use of unpatched software as an initial attack vector (Eira, 2019). Cyberactivism in which cybercrimes are committed for a political cause was recognized as a trending cybersecurity concern. An argument was made that encrypted communication applications such as Jaber and WhatsApp are being adopted by cybercriminals for communications to provide anonymity and increase difficulty in tracking down the threat actors (Sindelar & Ferguson, 2021).

III. METHODOLOGY

This systematic literature review strives to focus on the research problem of identifying contemporary threats and key trends in cybercrime at the present time. As significant effort has been undertaken and circulated in a variety of settings and by many organizations, a systematic literature review was conducted to research this problem. The research methods and questions utilized to reach the conclusions are discussed in the remainder of this section.

Analyzing the Emerging Trends in Cybercrime

The main research question that this analysis is centered around was "what are the current threats and trends that have been identified in recent research in the Dark Web and cybercrime?". To identify appropriate resources, a few research questions were created.

RQ1: What is the relationship between Dark Web and cybercrime?

RQ2: Does the research provide insight into cybercrime activity that is accelerating in occurrence?

RQ3: What has changed in the cybercrime ecosystem?

RQ4: What benefits do these new trends provide cybercriminals?

RQ5: Why are these cybercriminal activities trending?

RQ6: What are the implications to the victims to the trending cybercrimes?

RQ7: What date was the research work published?

Relying on the topics pertaining to the questions above, Google Scholar, IEEE Xplore, and UC's Grover M. Hermann Library search utilities were used to locate scholarly journal entries and articles. The same topics from the questions were used to search for well-known independent news articles and blog posts. While conducting the research of the sources identified during these searches, each individual source was evaluated based upon applicability to the selected topics regarding cybercrime, emerging trends, and publication time.

IV. RESULTS

Cybercrime is undergoing a swift evolution which has developed into a well-structured ecosystem. Ransomware incidents have intensified substantially in recent years. Organizations that were subjected to attacks have almost doubled since 2021. The scale of transformation continues to accelerate with organizations financing many advancements in technology to increase efficiency and remain competitive (Bowers, 2018). Currently, IT systems are being enhanced for adopting remote work as part of the normal paradigm, augmenting consumer interfaces, and producing benefits which all give rise to threats and risks. For instance, during COVID-19, the workplace strategy shifted to enable work-at-home for nearly 50 percent of employees which heightened wireless internet connectivity usage within homes to attach to company networks which represents a reduced security connectivity model for employee communication.

Simultaneously, cybercriminals have organized into mature associations making use of a cohesive toolset with contemporary strategies including machine learning and artificial intelligence. Greater efficiency will be a goal of cybercriminals to enhance the return on investment of both time and resources (Cerulus, 2021). As emerging technologies become mainstream, cybercriminals are

learning how to weaponize these to facilitate an even greater amount of damage and interference. This can be seen in enhancements to cyber threats which are growing progressively ubiquitous through continued advancements and operational efficiencies which has led to the commoditization of cybercrime and the introduction of a managed services pattern (Paganini, 2020). The amount and variability of cyber threats will sustain work for security personnel well into the future. Organizations of all sizes are currently confronted with the same threats with none being impervious. Management from all organizations must continually evaluate and improve their security controls and apply their current technology investments to mitigate threats over the next few years (Consulting, 2023).

Threats & Trends

Presented below is a comprehensive list of identified threats and emerging trends. This catalog serves as a compilation illustrating the extensive analysis conducted to demonstrate the intrinsic research performed:

1. Novel technology usage by cybercriminals will continue to increase. For instance, criminals will adapt to using artificial intelligence as part of their attack regime. Cybercriminals are currently using AI to evolve their attacks so that they will be more successful. AI is currently used for credential deduction, bypassing CAPTCHA controls, emulating voices, and evading other security controls. This trend is expected to evolve with significant advances in malicious innovations to intensify future cybercriminal activities. Some innovations are expected to include social engineering to trick users into navigating to malicious sites or revealing confidential data. Another use of AI is the development of videos called deepfakes, which will superimpose a targeted individual's face in a video performing activities they did not participate in (Zhang & Zou, 2020). Other cybercriminal activities that could be augmented by AI include writing technique impersonation, the deployment of chatbots to perplex victims, software development performed directly by AI, and the inclusion of AI directly into malware and ransomware to amplify results. AI and ransomware will increase vulnerabilities identified and locate victims while assisting with detection evasion. The scale of cyber-attacks is expected to continue to grow because of the efficiencies that AI provides for cybercriminal operations (Holmes, 2024).
2. As organizations have transformed into a business model that facilitates employees working from home more regularly, cybercrime trends are expected to continue to adapt to this model. The perimeter will be extended to include home networks as work equipment will continually relocate between different security zones represented by the home network and the secured network of the organization. Cybercriminals will attempt to take advantage of this with lateral movement between home networks and the organizations' networks (Cascavilla et al., 2021). One such cyber threat is related to phishing attacks centered around COVID-19 related topics. The cybercriminals act as if they are healthcare or governmental organizations to engage victims to respond regarding federal aid or healthcare-related benefits using alarmist rhetoric.
3. Malware has become a mounting threat as it has transformed into a more efficient cybercriminal business model by developing malware-as-a-service (MaaS). Enhanced malware is expected to lead to many attacks targeting the theft of credentials, money, and confidential data (Adewopo et al., 2020). As more individuals work remotely, exposure to malware exploitation continues to increase. Cybercriminals desire to target home networks as they are usually less secure than organizational infrastructure and have firewalls, routers, and other network devices that are not configured securely. Remote work distorts the boundaries of personal and work cultures, which raises the possibility that confidential data could be compromised. This enables a more significant number of cybercriminals to conduct operations using malware given that only a small group of individuals can create malware development capabilities.
4. Ransomware is also a rising threat. It has grown to include over 120 distinct families as cybercriminals have become more skilled in concealing malicious instructions inside seemingly legitimate business applications. As with malware, targets have been created due to the new remote work paradigm developed during the COVID-19 pandemic (Holt, 2012). In turn, the number of attacks and ransom has ballooned. The trend is for ransomware to become increasingly advanced through distribution within the Dark Web and the deployment of ML and AI into the code. Ransomware has evolved to begin using malware called "Wiper" which is more devastating and advanced than previous strains. Payloads will be enhanced to enable data extortion as well as to

be cloud-aware and the addition of the wiper malware is a sign that these attacks will likely be combined with other cybercrime tactics in the future. This represents a new pattern for coercing payment from the intended target.

5. Damaging data denial incidents will become even more devastating and are expected to begin targeting time-sensitive information generated by real-time sensors such as those found in Internet-of-Things (IoT) devices.
6. Manufacturing and related industries will be the victims of more targeted attacks using Advanced Persistent Threats (APT) techniques conducted by nation-states.
7. Another trend due to technological advancement is the proliferation of IoT into an attack surface that has dramatically expanded. Given the increase in IoT devices, there has been a 300 percent rise in attacks on IoT endpoints from 2018 to 2019. It is more challenging to enable security controls for IoT devices such as antivirus and firewalls because they have lower storage capacity and less processing power [8]. Attacks on IoT devices can be used to steal data, perform DoS attacks, lock access to critical devices for direct monetary benefit, and inflict environmental or personal harm.
8. Another expanding trend is crypto-jacking, a specific malware attack type designed to compromise a computer and use the computer's resources to perform cryptocurrency mining. Cybercriminals consider this attack method low-risk and easy to conduct, resulting in a continuous flow of revenue. Crypto mining-related malware has become highly available, making this threat something that will continue to increase in popularity among cybercriminals (Eira, 2019). There are many possible targets with minimal effort for payout and any foothold achieved with crypto-jacking could also be used to exfiltrate data.
9. Another technological trend that continues to spread is the deployment of corporate resources using cloud services which have caused security concerns for institutions. Cloud environments have been implicated in various exploits resulting in information leakage and unauthorized access, interfaces that have not been configured securely, and the hijacking of user accounts (Świątkowska, 2020). Security controls are expected to be inconsistently applied to cloud deployments since many security organizations do not have the experience or bandwidth to manage cloud environments. This will lead to misconfigurations as well as delays in implementing security controls as the development of the cloud environment occurs.
10. Social engineering is expected to adapt to the increased use of remote work culture as personnel working from home are less complicated victims. These social engineering attacks include phishing, SMS phishing (smishing), and voice phishing (vishing). New phishing attacks are expected to adopt ML to streamline the creation and dissemination of persuasive fraudulent messages to trick victims into providing unauthorized access to their organization's infrastructure (Security, 2022). The number of smishing attacks is increasing because of the elevated use of mobile applications such as Skype, Microsoft Teams, Zoom, WhatsApp, WeChat, and Signal. These applications are targeted to deceive users into installing malware onto their mobile devices (Anzaruddin et al., 2024). Using vishing, employees are deceived by cybercriminals impersonating IT helpdesk employees and tricked into authorizing access to critical systems.
11. Another emerging trend is the increased concentration of malicious actors bypassing multi-factor authentication (MFA) techniques. Cybercriminals are concentrating on efforts to dissect MFA carried out through SMS and phone calls.
12. Recent developments in automobile-related technology have exposed them to direct exploitation, allowing the theft of sensitive information and the actual theft of the automobile. They can directly instigate harm upon the drivers.
13. Many new concerns regarding mobile technology are being identified including spyware, vulnerability exploitation, and mobile malware. With spyware, cybercriminals can interact with applications responsible for encrypted messaging (Kelly, 2023). Mobile malware has introduced several security situations including data theft, spam over SMS, DDoS attacks using mobile devices, and compromising inadequate password security.
14. As satellite-based internet networks have become mainstream with additional size and dimension, they have also presented themselves as a new attack vector for cybercriminals. The most prominent targets for satellite-based attacks are organizations with low latency requirements delivered through the connectivity provided by

satellite-based internet networks (Fortinet, 2022). These organizations are within the transportation, shipping, and energy business sectors. Also, cybercriminals have targeted satellite communications in Ukraine due to the ongoing conflict. Cybercriminals seek to compromise these satellite networks to conceal their activities so that they can remain anonymous.

15. An increasing number of new attack vectors are enabled through the Dark Web as CaaS business offerings. As an extension to RaaS and other MaaS capabilities, new illicit services are expected to surge with a continued sale of subscription-paid crime services. The subscription-based offerings enable cybercriminals with rudimentary skills to launch advanced attacks with minimal investment of time, finances, and resources to develop a distinct tailored strategy (Weigand, 2023). This service offering enables experienced cybercriminals to quickly sell attacks based on their skills while providing a reliable income stream. As there is demand from unskilled cybercriminals and supply from experienced cybercriminals, the trend is expected to see CaaS expand offerings in 2023 and the future. New emerging attack vectors are expected to be offered by cybercriminals such as deepfakes creation technology for sale (Boehm et al., 2022). Reconnaissance-as-a-service is likely to improve in demand with cybercriminals employing researchers to obtain intelligence on selected targets before executing an attack.
16. Another anticipated direction for the future of money laundering is that cybercriminals will use ML to improve the recruitment of money mules by identifying better targets and making the mule recruits' location more efficient (Security, 2022). Operational improvements are expected to be made for manual mule campaigns to transform them into automated services to transport money through a variety of crypto markets to expedite the movement procedure as well as to conceal the money transfer process while lowering the probability of fund recovery in the end (Top Cybersecurity Threats, 2023). Money Laundering-as-a-service is anticipated to be an integral part of the CaaS portfolio in the near future which will decrease the manual recruiting of mules and possibly remove it entirely.
17. The development of business email compromise (BEC) scams will continue to flourish with progressively directed attacks. BECs selected as cyber-attack targets generally had relationships with overseas suppliers and performed online money transfers (Eira, 2019). During these attacks, the cybercriminals will mimic the merchants or clients to compromise monetary transfers and send the money to attacker-owned accounts.
18. As alluded to in some of the other predictions, cooperation and specialization are occurring in the world of cybercrime. Cybercrime has evolved to be performed by coordinated units of hackers. Specialization in different forms of cybercrime is also occurring including the publishing of viruses, the theft of confidential information, the performance of DDoS attacks, and the compromise of networks owned by organizations (Morgan, 2020). Collaboration and specialization enable the execution of highly complex and destructive operations that an individual hacker may not be able to perform alone.
19. Cooperation between nation-state threat actors and cybercriminals is an expanding threat with broad repercussions. Nation-states can offer cybercriminals many resources and skills to execute advanced attacks while cybercriminals seek monetary gain and are inclined to work for more significant compensation (Cerulus, 2021). Together, these considerations make it predictable that increasingly advanced cybercrime will occur.
20. Small-medium businesses (SMBs) are expected to become increasingly targeted since they lack robust threat detection and prevention controls.
21. Cyberactivism is a trending type of cybercrime in which protesters struggle for a specific political cause. One main focus is to interfere with the operations of an organization's website to send a message to management or to communicate knowledge regarding harmful activities performed by an organization.
22. Supply chains will continue to be targeted by cybercriminals through selected vulnerabilities concentrating on third-party-provided components within an organization's environment.
23. The proliferation of encrypted communication by cybercriminals is continuing to increase. This is important for cybercriminals because encrypted communications retain anonymity and are challenging to track (Carmiel, 2022). Law enforcement agencies are severely hampered by encrypted communications, which makes it extremely tricky to decrypt communications with details of criminal activities.

24. Cryptocurrency, specifically Bitcoin, has developed into the most prevalent ransom payout mechanism due to its anonymity, decentralization, and value.
25. Unpatched vulnerabilities remain a preferred path of compromise by cybercriminals who continuously search the internet for instances of these vulnerabilities. Upon discovering an example of the vulnerability, the cybercriminals will exploit the vulnerability to compromise the system.
26. Remote Desktop Protocol (RDP) has evolved into a primary entry point for cybercriminals to obtain a foothold in an organization with targets with SMBs typically being targeted (Glas, 2021). Credentials for RDP grant remote access into an organization's ecosystem, which can be used to exfiltrate data or lock access to critical systems.
27. Due to IoT technology, 5G cellular phones can relay information 300 percent quicker than 4G cellular phones, along with the capability to integrate more individuals and computing equipment. 5G, in turn, has manifested into a target for cybercriminals to make their malicious operations more practical and efficient.
28. As organizations integrate significant data architecture into their operations, they have begun to gather large amounts of behavioral data regarding clients, vendors, and partners ranging from energy usage to financial information and social networking platforms. With this expansion of data collection, cybercriminals continue to target and exploit significant data infrastructure components.
29. The latest online applications use many contemporary technologies including virtual, augmented, and mixed reality, providing end users with a highly innovative interface. These technologies have virtual resources associated with the accounts related to the users making them ongoing targets for cybercriminals, and attacks targeting these resources are expected to rise (Świątkowska, 2020).

The pie chart highlights the distribution of standard cybercrime attack methods such as Social Engineering, Ransomware, Phishing, and IoT Vulnerabilities.

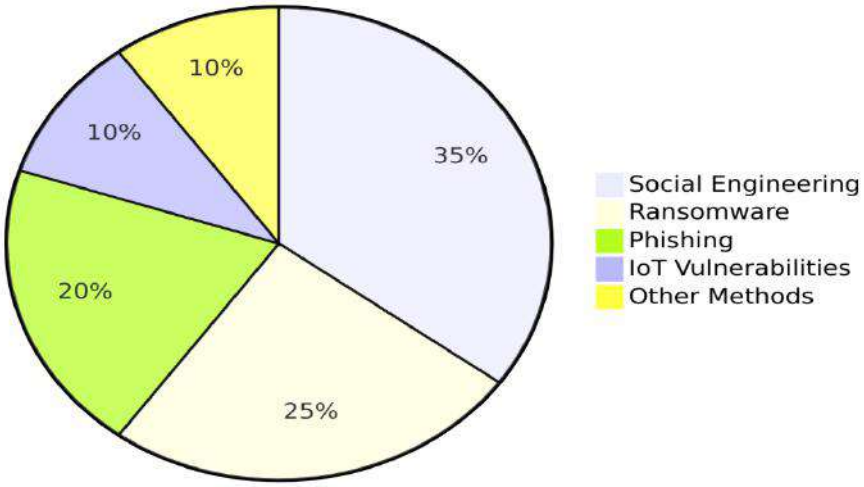

Fig.3: Common Cyber-attack Methods

V. DISCUSSION

Innovative progress has recently accelerated, including organizational shift into cloud environments and further individual adoption of mobile and contactless technologies. The digital ecosystem has continued to extend for companies and individuals, which has expanded the attack surface by exposing security gaps that have yet to be adequately addressed and thus left open for cybercriminals to exploit (Kelly, 2023). The capabilities and tactics used by cybercriminals have shifted to be increasingly more successful and proficient by creating new business strategies to offer hacking skills as commoditized services.

Understanding Cybercriminal Behavior

A criminological perspective provides valuable insights into the underlying mechanisms driving the growth and sophistication of cybercrime on the Dark Web. Routine Activity Theory (RAT) is relevant in explaining why

cybercrime has increased in recent years. According to RAT, a crime occurs when three conditions converge: a motivated offender, a suitable target, and the absence of capable guardianship (Özaşçılar et al., 2024). The anonymity of the Dark Web provides offenders with a high level of protection from detection and prosecution creating an environment where motivated offenders can easily find suitable targets such as vulnerable systems, and organizations with weak cybersecurity practices without immediate risks of being caught. The emergence of RaaS and CaaS commodified cybercrime making it easily accessible. This development is supported by Rational Choice Theory which posits that criminals weigh the potential rewards of their actions against the risks and costs (Steinmetz & Pratt, 2024). The low risk of apprehension combined with the lucrative rewards of cybercrime such as large ransom payments makes this a rational choice for many individuals when sophisticated hacking tools can be purchased or leased easily. Strain theory suggests that individuals turn to crime when they cannot achieve socially accepted goals through legitimate means which further explains the rising engagement in cybercrime (Meehan et al., 2024). Economic disparities and limited employment opportunities in regions suffering from prolonged recessions or in post-pandemic recovery push individuals toward illegal cyber activities, which offer an alternative means of achieving financial gain in a low-risk environment.

The Role of Economic Instability

The rise of cybercrime on the Dark Web cannot be fully understood without considering the socio-economic factors. The global economy has faced significant challenges in recent years including economic downturns, rising unemployment rates, and the destabilization brought about by the COVID-19 pandemic. Individuals with technological skills may turn to cybercrime as a form of income generation in times of economic uncertainty. Cybercrime offers a low-barrier entry into illicit activities when services like CaaS provide pre-packaged tools for launching attacks. This democratization of cybercrime parallels the broader economic shifts towards "gig economies" and "on-demand" services where individuals look for flexible, non-traditional income streams. The Dark Web provides a platform for income generation that appeals to those on the fringes of the economy as legitimate employment opportunities become more uncertain. Socio-political instability in certain regions has led to the emergence of cybercriminal groups with political or ideological motivations. For instance, hacktivist groups may exploit the Dark Web not only for financial gain but also to promote political ideologies or challenge governmental control. These cyber actors often justify their actions as protest or resistance against political and economic systems they perceive as oppressive.

The Impact of Anonymity and Deterrence

The anonymity afforded by the Dark Web plays a critical role in encouraging individuals to engage in illicit activities that they might not otherwise consider in a more transparent environment. De-individuation theory helps explain this behavior as it suggests that when individuals feel anonymous or part of a crowd, they experience a loss of self-awareness and are more likely to engage in behaviors that violate social norms (Martin Coesel et al., 2024). The Dark Web with its layers of encryption and use of anonymizing tools like TOR fosters this de-individuation by allowing individuals to act with a reduced sense of accountability. Deterrence theory implies that individuals are less likely to commit crimes if they perceive the likelihood of being caught and punished to be high (Klusek, 2024). The perceived lack of deterrence plays a significant role in motivating criminal behavior. Cybercriminals operating on the Dark Web often believe they are beyond the reach of law enforcement due to the complexities of tracking digital activities across borders. This perceived impunity creates an environment where even the most destructive forms of cybercrime such as ransomware attacks on critical infrastructure can be carried out with minimal fear of consequences. The lack of immediate punishment or visible harm may also distance cybercriminals from the consequences of their actions allowing them to rationalize their behavior. Unlike physical crimes where the damage is more tangible, cybercrimes often affect distant victims whom the perpetrator never sees reducing any sense of personal responsibility.

Challenges in Cyber Law

The rapid evolution of cybercrime also reflects the inadequacies in the current legal and regulatory frameworks governing cyber activities. International law enforcement agencies face significant challenges in prosecuting cybercriminals operating on the Dark Web. The anonymity and decentralized nature of the Dark Web make it difficult for law enforcement to track and apprehend individuals who often operate in jurisdictions with weak or non-existent cybercrime laws (Ruddin & SGN, 2024). This lack of robust international cooperation and harmonization of cyber laws creates a haven for cybercriminals. Nation-state actors can use the Dark Web to outsource attacks to leverage the skills and services of cybercriminal groups to engage in economic espionage, intellectual property theft, and even the disruption of critical infrastructure in rival countries (Li, 2024). These attacks are often politically motivated but are conducted in a way that offers plausible deniability for the state actors involved.

Developing more comprehensive and enforceable cyber laws is imperative as cybercrime intersects with national security (Joshi, 2024). The pace at which cyber laws evolve lags behind the rapid innovation in cybercrime techniques. The commoditization of cybercrime services such as RaaS has transformed hacking from a niche skill into a service available to virtually anyone including individuals who may not fully understand the legal ramifications of their actions (Buçaj & Idrizaj, 2025). Governments and regulatory bodies must catch up by creating more transparent and enforceable cybercrime laws that reflect the complexities of the modern digital landscape. The European Union's General Data Protection Regulation (GDPR) and similar data protection frameworks offer some hope as they impose strict regulations on data handling and cyber responsibilities. However, these regulations mainly apply to legitimate organizations leaving the Dark Web largely unchecked (Russin & SGN, 2024).

VI. CONCLUSION

Cybercrime continues to transform and accelerate along with technological advances that have occurred in recent times. The Dark Web has facilitated cybercrime's evolution by supplying an ecosystem enabling collaboration, sharing and distribution of ideas and tools, an organization for planning criminal activities, training venues, and stores that trade criminal merchandise, services, and information. There are multiple factors contributing to emerging trends in cybercrime. The main factor that continues to contribute to the acceleration of cybercrime is unpatched software and infrastructure components commonly used as an anchorage for cybercriminals to obtain unauthorized access to organizational networks. Another critical factor is the commoditization of services to facilitate cybercrime which allows individuals with novice skillset to continue sophisticated cybercrime activities while at the same time producing a revenue stream for accomplished cybercriminals with in-demand skills. Also, contemporary technologies such as artificial intelligence and machine learning, satellite communication networks, IoT devices, automobiles with computing interfaces, 5G network rollout, migration from corporate data centers to cloud environments, and the proliferation of big data technologies provide new avenues with security issues that cybercriminals can exploit. Another factor that has led to the acceleration of cybercrime is the migration of employees to a remote working model which has elevated the attack surface for organizations.

VII. DIRECTIONS OF FUTURE STUDY

Cybercrime is expected to accelerate further as novel technologies emerge. Quantum computing, while still in its infancy will likely lead to a drastically improved computing environment. When this occurs, the computing power could render many existing encryption methodologies obsolete overnight leading to the compromise of confidential information otherwise protected in today's computing environment. Virtual goods in augmented reality and virtual reality settings are expected to become targets of cybercrime activities in the near future. As AI applications continue to proliferate and evolve, cybercriminals will use these applications to develop more efficient and illicit lucrative schemes. Lastly, deepfake technology is expected to become highly realistic with cybercriminals currently planning scenarios to trick individuals into interacting with familiar voices and faces to extort money and information.

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Availability of data and materials

Data sharing does not apply to this article as no datasets were generated or analyzed during the current study.

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Authors' Contributions

ST designed the study, conducted the research, collected and analyzed the data, and wrote the manuscript. ST read and approved the final manuscript.

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Effective Virtual Call Center with Free PBX Technology

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***Keywords*— evolution of call center, Linux Virtual machine, PBX Simulation, VM Simulation, and Web-based call center**

***Abstract*—** *A call center manages new and existing client questions and issues with the help of skilled specialists. Existing customers answer new consumers' inquiries and concerns. These questions may come from new or existing clients. Call centers are important in Rwanda as they enable companies to monitor calls. Companies can also analyze their markets through data acquired through call centers. However, setting up a call center is expensive. The running costs of a call center are also large. Businesses that operate call centers spend a lot of money running them, consequently reducing their profits. Therefore, this study proposes a cheaper technique for handling call traffic implemented using free PBX, which is a Linux based web-application for monitoring call traffic. From the results of the simulations carried out, a fast connection between mobile phones was observed. Moreover, it was determined that the capacity of free PBX is unlimited, making it ideal for use in call centers. The analysis shows that this project can be implemented in different institutions on chipper prices. The existing cost of implementing a call center on 50 users using hardware PBX is 100.000 USD, whereas, with the proposed solution using FreePBX which is a Linux based web-application for monitoring call traffic, the implementation cost can be between 5000 USD and 10000 USD with the same range of users. The discounted price as compared to the existing system can be estimated to be around 90%, which is much cheaper.*

I. INTRODUCTION

A call center is a department or office that manages all of the questions and concerns that are asked by new customers in addition to those that are addressed by existing customers with the assistance of a team of trained specialists. The questions and concerns that are asked by new customers include those that are addressed by existing customers. These inquiries and concerns may originate from either newly acquired or already established clients (Aksin, *et al.*, 2020).

A call center is also referred to as a contact center on occasion. This may comprise inquiries and concerns raised not only by new clients of the organization but also by those who have previously done business with the company. This category may include customers who are new to the establishment as well as those who have been coming to the place regularly for some time. These employees are able to respond to customers in real time and offer answers to any questions or concerns that customers may have regarding their purchases (Ang, 2019).

In the context of the highly competitive business environment of today, some companies view it as an unwelcome but unavoidable need, whereas other

organizations view it as an opportunity to earn a return on the investment they've made. This dichotomy can be attributed to the fact that some businesses view it as an unwelcome but unavoidable need, whereas other organizations view it as an opportunity This seeming contradiction can be explained by the fact that certain companies and organizations view it as an undesirable but inevitable requirement, whereas other businesses and organizations view it as an opportunity. This seeming paradox can be resolved by noting that some businesses and organizations perceive it as an unwelcome but unavoidable requirement, whilst other companies and organizations see it as an opportunity. This seeming contradiction can be reconciled by recognizing that some firms and organizations view it as an unwanted but inescapable requirement, whilst other businesses and organizations view it as an opportunity (Bhatnagar, 2021).

In any case, however, the demand is unavoidable. This seeming paradox can be resolved by acknowledging the fact that some businesses and organizations perceive it as an unwelcome but unavoidable need, whereas other businesses and organizations see it as an opportunity for growth and advancement. In any event, meeting the demand is something that can't be avoided. It is possible to find a solution to this apparent contradiction by recognizing the reality that some companies and organizations view it as an undesirable but inevitable requirement, whereas other companies and organizations view it as an opportunity for expansion and improvement in their operations. In any case, satisfying the demand is an obligation that simply cannot be sidestepped. It is possible to find a solution to this apparent contradiction by recognizing the reality that some companies and organizations view it as an undesirable but inevitable requirement, while other companies and organizations view it as an opportunity for expansion and improvement in their operations (Bhatnagar, 2021).

By acknowledging this reality, it is possible to find a solution to this apparent contradiction. In any event, gratifying the demand is an obligation that just cannot be avoided under any circumstances. Both points of view are valid and deserve to be taken into consideration, especially when viewed in the context of the highly competitive corporate atmosphere that characterizes the world at the present moment. Both points of view are valid and deserve to be taken into consideration. Both points of view are valid and should be taken into consideration because they both deserve to be heard. It is possible that any one of these points of view is correct in light of the events that have taken place given the current state of affairs. In other words, it is possible that all of these points of view are correct. It is not impossible that each and every one of these points of view is accurate (Charoensukmongkol, *et al.*, 2022).

To put it another way, there is a chance that each and every one of these points of view is correct. It is not at all implausible that this is the condition of circumstances at the moment. In addition to this, there is the possibility that each and every one of these points of view is correct. Someone who is in control of a call center or contact center is required to have a very high level of attention, in addition to being aware of what is going on within the center itself. This level of attention is paid not only to what is occurring outside of the center, but also to what is occurring within the center itself. It is essential to carry out these steps in order to guarantee that the customers will be provided with the highest possible standard of service that is available in the industry at the present time. This is a direct result of the fact that individuals in charge of such a center need to be aware of what is happening within the center itself in order to manage the center in an appropriate manner. In order to manage the center in an appropriate manner, these individuals need to be aware of what is happening within the center. These individuals have a responsibility to be informed of everything that is going on within the center so that they can effectively manage it in the appropriate manner (Cleveland, *et al.*, 2019).

Call centers are of great importance in Rwanda as they enable companies to monitor calls. Companies are also able to analyze their markets through data acquired through the call centers. However, setting up call center is expensive (Zhang, *et al.*, 2022). The running costs of a call center are also large. Businesses that operate on call centers end up spending a lot of money running them, consequently reducing their profits. A need, therefore, arises to devise a cheaper technique for handling call traffic. Management of existing call centers also requires a lot scripting commands that are not effective to all call center administrators.

In order to achieve the main objective, the following are the key objectives: the first key is to test the viability of the FreePBX web-based system as a call center. The second key is to determine the effectiveness of the web-based application in handling and analyzing calls. And the third is to modify the application so as to increase its efficiency and capacity.

II. RELATED WORK

The only kinds of services that can be obtained through a call center of any kind are the kinds of services that are connected to voice communication in some fashion or

another. The provision of any other kinds of services is not possible at this time. There is no other type of enterprise other than a contact center that is able to provide the services that it does; this makes it the only viable option. Because call centers are only able to provide the types of services that are listed above, they are unable to provide any other types of services to their customers besides those listed above (Deng, 2022).

This could encompass a wide range of activities, such as providing assistance to customers who have already made purchases from the company or taking incoming phone calls from customers who have questions regarding their orders. a. As a consequence of this reality, the primary responsibility of customer service representatives working in conventional contact centers is to make or receive phone calls from end users and to actively listen to the difficulties that are being experienced by those end users. After that, it is of the utmost necessity that you provide them with the appropriate solutions to the problems that they are now dealing with and that you do so as quickly as you possibly can (Gans, 2020).

In addition, it is of the utmost promising that you provide them with the appropriate solutions to the problems that they are now dealing with. After that, it is of the biggest significance that you present them with the suitable solutions to the problems that they are now struggling with. You must do this as soon as possible. After that, it is of the utmost importance that you give them with viable answers to the issues that they are currently having trouble coping with. You have an immediate obligation to carry out these steps. After that, it is of the utmost importance that you provide them with feasible answers to the challenges that they are now having trouble coping with (Golembiewski, 2018).

It is imperative that you carry out these procedures as soon as possible. Following that, it is of the utmost importance that you provide them with workable solutions to the challenges that they are currently having trouble coping with. You need to get started on this as soon as you can. It is of the utmost importance that you complete these steps as quickly as you possibly can. This is due to the fact that people look to you as a source of leadership and guidance, which is a direct result of the fact that they do so (Kumar, 2022).

Consequently, this is a result of the fact that they do so. People look to you as a source of leadership and direction, which is why this is the case. On the other hand, when it starts to provide additional services, eventually the call center will transition into a contact center. This will occur when it begins to provide those additional services. The administration of live chats, the management of email correspondence, and the transmission of messages will all be included in these supplementary service offerings, among other things. All of these activities serve as illustrative examples of actions and duties that a contact center may be able to carry out, and they are listed below as a list of tasks that may be able to be carried out by a contact center for your convenience as a list of activities that may be able to be carried out by a contact center (Kumar, 2019).

On the other hand, in this day and age, the vast majority of companies are able to provide responses to the questions that are posed by customers through the utilization of live chats, emails, and telephone conversations with customers. The evolution of various methods and forms of communication technology is to blame for the current state of affairs. There have been significant developments made in the technology that is utilized for communication, and this is the reason why this is the case. The reason why this is the case is because of these technological advancements. This state of affairs has arisen as a direct result of the recent advances that have been made in the fields of information and communication technology over the course of the past few years (Kumwilaisak, *et al.*, 2022).

The significant developments that have been made in the technology that is used for the purpose of communication are the reason why this is the case. The fact that this is the case is due to the fact that this is the reason why this is the case. This phenomenon can be traced back to the creation of new technologies, which helps explain why it has come to pass in the first place. When compared to the generations that came before it, this represents a significant advancement in terms of the technological and scientific development that has been achieved. When it comes to the management of a company, the utilization of each of these numerous communication channels is widely acknowledged as a best practice across the entirety of the industry as a whole. When referring to businesses that provide assistance to customers while they are conducting business, the terms "call center" and "contact center" are frequently used interchangeably by a significant number of people. This is particularly prevalent in the United States (Butler, 2020).

During the course of doing business, these companies offer their customers various forms of assistance. This is the conclusion that one must reach in order to make sense of the information that was presented earlier in the conversation. As a result of the fact that call centers are currently an essential component of the day-to-day operations of a significant number of businesses, it is anticipated that the importance of call centers to the

overall economy will continue to grow in the years to come. This is one of the primary reasons why this trend is anticipated to occur. This is as a result of the fact that call centers are now an integral part of the day-to-day operations of a considerable number of different enterprises (Li, 2022).

It is anticipated that this pattern will persist for a variety of reasons, one of the most significant of which is the following: It is anticipated that this trend will continue for a variety of explanations, with the following constituting one of the most significant of those explanations: They are also fascinating instances of sociotechnical systems due to the fact that the actions of customers and employees are strongly entangled with indicators of both workers' and customers' physical performance. This makes them particularly interesting sociotechnical systems. Because of this, both of these systems are remarkable examples of their respective types. As a consequence of this, each of these systems are exceptional illustrations of the kinds to which they belong (Mehrotra, 2019).

As a result of this, having a discussion about them is one of the activities that is capable of producing the most interesting results. The study of sociotechnical systems is, in and of itself, one of the most fascinating elements of sociotechnical systems.To put it another way, the capability of standard operational models to characterize the performance of a system is, to put it in the most straightforward terms imaginable, inherently constrained. This is due to the limitations that were covered earlier in the discussion. This constraint is an unavoidable consequence that arises as a direct result of the restrictions that were discussed in the paragraph before this one. Even if these models are beneficial in a wide variety of ways, the current situation has not changed despite these models' existence (Murthy, 2019).

In spite of the fact that these models are helpful in a great many different ways, this is the case for some reason. Despite the fact that these models are highly significant, it is not possible to assess the efficiency of the system using them because of the limits that are built into these models. This is the case despite the fact that these models are very significant. Traditional models, despite the significance they bear, have a capacity that is fundamentally restricted in their ability to characterize the performance of a system. This is because traditional models were developed using methods that are no longer applicable. In these kinds of situations, classic operational models offer a wide range of important advantages; despite these advantages, however, traditional models still have some limitations (Nina-Mollinedo, 2022).

Call centers are utilized in virtually every industry and field of work imaginable in the modern world, and the practice of engaging the services of these facilities is becoming a trend that is becoming increasingly commonplace. In addition, call centers are utilized in virtually every country in the world. In addition, call centers are utilized in almost every nation on the face of the planet. Call centers are utilized in virtually every industry and field of work that can be imagined of in today's modern world. Call centers are particularly prevalent in the retail and telecommunications sectors (Rowe, 2019).

When a firm uses the services of an outsourced call center, it is able to have access to resources that it otherwise would not have. These resources could include personnel, technology, and more. These resources could consist of manpower, technological advancements, and much more. These resources may take the form of humans, technical developments, and a variety of other possibilities. This is due to the fact that call centers often staff their operations by employing a sizeable number of people. This is because call centers have access to a wide variety of both technological and human resources, which enables them to provide superior customer care and makes it possible for them to do so. Because of this, call centers are able to provide better support to their clients. This is because, rather than the company itself being in charge of the operations of the call center, a separate organization is in charge of such obligations (Sencer, 2019).

As a result, this situation has come about. This is because call centers have access to a wide array of resources, both technological and human. The reason for this is that call centers can better serve customers. This not only makes it possible for them to provide superior service to their customers but also provides them with the ability to do so. As a direct consequence of this element, call centers are in a position to provide their clients superior levels of customer support. This is due to the fact that the call center has engaged into a contract with a third-party vendor to handle specific areas of its business operations, which will ultimately result in the vendor handling those aspects of the company operations (BasarirOzel, 2021).

This is due to the fact that the call center has a contract in place with a third-party vendor to manage some areas of its company operations. The rationale for this can be seen in the previous sentence. This has resulted in the current predicament, which is a direct consequence of this. If this company did not make use of the services that are given by the call center, it would not be able to have access to the resources that are being discussed in this text. One example of how the term "outsourcing" can be used to

refer either to the process of outsourcing in and of itself or to the procedure that occurs when a company does so is the procedure that occurs when a company enters into a contract with a third-party call center to meet its customer service obligations(Sienes, 2022).

This is an example of how the term "outsourcing" can be used to refer either to the process of outsourcing in and of itself or to the procedure that occurs when a company does so. An illustration of how the term "outsourcing" can be used to refer either to the practice of outsourcing as it is in and of itself or to the procedure that takes place when a corporation does so is provided here. This serves as an example of how the term "outsourcing" may be used to refer either to the process of outsourcing as it is in and of itself or to the method that takes place when a firm does so. Both of these meanings can be attached to the phrase "outsourcing." An illustration of how the term "outsourcing" can be used to refer either to the practice of outsourcing as it is in and of itself or to the method that takes place when a company decides to outsource work is provided here (Singh, *et al.*, 2021).

One illustration of how the phrase may be used to refer either to the process of outsourcing as a practice in and of itself or to the procedure that takes place anytime a firm decides to engage in such a practice is presented here. This is just one example of how the term can be used. The following grammatical construction offers another illustration of the term's potential applications. Both the process that takes place when a company enters into a contract with a third-party call center to meet its customer service requirements and the activity that takes place when the company does so are referred to as "outsourcing." Outsourcing is a term that is used to describe both of these things. When a company engages in the process of outsourcing, the term "outsourcing" is used to refer to both the process that is followed and the activity that is carried out by the company (Smith, 2021).

There are two distinct actions that can be referred to by the term "outsourcing" when referring to a corporation that engages in this activity, and both of these activities are described here. The first activity is the procedure that is carried out, and the second activity is the operation that is carried out as a direct result of the first activity. The term "outsourcing" can refer to any of these two different types of activity. Call centers typically have the capabilities that are required to manage unusually high contact volumes for a wide variety of clientele and services. These characteristics may be found in call centers all over the world. Call centers typically have the capacity to do these functions. These contact volumes may have originated from any one of a number of different locations all across the world. There are call centers established in every area of the world, and each one of them is geared up to offer these services to the clients of the respective organization. Call centers can be found in every region of the world, and each one of them is geared up to provide these services to the customers of the particular firm that it serves (Taylor, *et al.*, 2021).

These characteristics can be observed in a considerable number of distinct contact centers that are situated all around the United States. Each day, there are possibly several hundred to several thousand new connections created. This number can range anywhere from a few hundred to several thousand. This Fig1 is subject to significant variation. Depending on the circumstances, the value of this number could range anywhere from a few hundred to several thousand. When compared to the lowest possible score and the greatest possible score, they are most likely to fall somewhere in the middle of the spectrum. As a direct result of this component of their business strategy, which provides them with a competitive advantage, call centers have an advantage over other companies operating in their area that offers them a competitive advantage (Tsai, *et al.*, 2022).

The organizational structure of the vast majority of call centers located all over the world is built on the basis of this paradigm, which can be summed up as follows. This paradigm is utilized to design the organizational structure. These call centers are present in virtually every nation on the face of the world. When you outsource your job to a call center, you significantly enhance the likelihood that you will have access to the most cutting-edge and up-to-date pieces of technological equipment. This is due to the fact that call centers are constantly modernizing and upgrading various pieces of equipment. This is only one of the many benefits that will come as a direct result of making this decision, which is just one of the many advantages. As just one of the numerous benefits that will come your way as a direct result of making this choice, you will also enjoy this one (Zhang, *et al.*, 2022).

This is just one of the many advantages that will come your way. This is just one of the numerous advantages that can be acquired when a firm hires the services of other people to carry out labor-intensive tasks for the operations of the company. There are many more advantages. One of the many benefits that arises as a direct result of contracting work to be performed by a call center rather than performing the work oneself is access to a wider selection of benefits. This is just one of the many advantages that arises as a direct result of contracting work to be performed by a call center. This advantage is simply one of the numerous benefits that emerge as a result of the

many advantages that develop as a result of delegating work to a contact center, which in turn develop as a result of the many advantages that develop as a result of delegating work to a call center (Aksin, *et al.*, 2020).

This advantage is just one of the numerous that arise as a result of assigning work to a call center, which also has many other perks. However, this is only one of those perks; outsourcing your job gives you access to a wide range of additional benefits, some of which are detailed in this article. However, this is only one of those benefits. One more advantage of contracting your work to a third party is that it enables you to enjoy financial savings. You will enjoy a greater degree of personal freedom and flexibility in your day-to-day life as a direct result of outsourcing the work that you do. The supplemental benefits that have been made available to you for the purpose of making access to them more convenient are described in the list that follows, which includes the following items: Call centers are the organizations that, in the vast majority of instances, are given the responsibility of delivering these services and are entrusted with doing so in order to carry out their functions (Ang, 2019).

This responsibility and trust is given to call centers in order for them to carry out their functions. Call centers are entrusted with this duty in order to guarantee that they are capable of performing the functions that are expected of them. Call centers are entrusted with taking on this obligation in order to ensure that they are able to successfully carry out the activities that have been assigned to them. Call centers that provide customer service typically have access to the most recent and cutting-edge technology that is presently on the market. This is the case in the majority of circumstances. Working in a call center comes with a number of benefits, one of which is that you get compensated for breaks (Bhatnagar, 2021).

The utilization of the services that are provided by a call center is not devoid of any potential drawbacks or disadvantages; on the contrary, these are both inherent in the nature of the service. The utilization of the services that are offered by a call center is not devoid of any potential drawbacks or downsides; on the contrary, the utilization of these services could genuinely have both potential drawbacks and drawbacks. The utilization of the services that are provided by a call center is not devoid of any potential drawbacks or disadvantages; on the contrary, the consumption of these services could really have both potential drawbacks and disadvantages (Bhatnagar, 2021).

The consumption of the services that are offered by a call center is not without the possibility of having possible drawbacks or disadvantages; on the contrary, the consumption of these services could truly have both potential drawbacks and disadvantages. In the vast majority of instances, the standard of service that is provided is not of the same high quality as it would be in the normal context of a commercial company. This is the case since commercial organizations strive to provide services of the highest possible standard. This is due to the fact that the majority of these locations are not owned by commercial businesses nor are they run by those establishments (Charoensukmongkol, *et al.*, 2022).

The reason for this is that most commercial companies adhere to a set of predetermined standards, which has led to the current predicament. This is the case due to the fact that, in general, settings that are more conventional have a tendency to be connected with greater levels of service quality. This is the case because, in the vast majority of instances, ensuring that the demands of the customer are met takes precedence over all other considerations and should be given the utmost priority. In point of fact, this is a completely spot-on appraisal of the situation in its current state as it stands right now in its current state as it stands right now. This holds true in the overwhelming majority of scenarios, and there are seldom any glaring exceptions to the rule that can be found (Cleveland, *et al.*, 2019).

This is correct in the overwhelming majority of circumstances. If you want to proceed in this manner, you need to be aware that it does not in any way, shape, or form provide any type of security, and you should keep this fact in mind at all times. If you want to proceed in this manner, you need to be aware that it does not provide any type of security in any way, shape, or form. If you want to proceed in this fashion, you need to be informed that it does not in any way, shape, or form provide any sort of security for you. This is just one of many reasons why you should steer clear of going down this route; there are many more reasons why you should avoid doing so. This is just one of the many reasons why you should steer clear of going down this path (Deng, 2022).

This is only one of the numerous reasons why you should avoid taking this route in your search for the best option. It is essential that you keep your distance from the object in question. Employees who work in call centers have the capacity to see personally identifiable information at any given time that belongs to thousands upon thousands of clients. This is made feasible by the nature of the work schedule in contact centers, which requires staff to work in shifts rather than in one continuous shift throughout the day. As a direct result of the fact that this is the case, there is a possibility that the capability of the system to supply

an adequate degree of security across the board may be compromised in some kind (Gans, 2020).

Contact centers, which are in charge of the management of the vast majority of call scenarios, frequently accept calls in a variety of formats and types and handle them in accordance with the format or type to which they belong. This is because contact centers are responsible for the management of the vast majority of call scenarios. Contact centers are responsible for managing the great majority of call scenarios, which is one reason why this is the case. This is because call centers are assigned with the responsibility of handling the management of the vast majority of call scenarios. This is due to the fact that contact centers have been tasked with the responsibility of managing the vast majority of possible call circumstances (Golembiewski, 2018).

This assumption is valid for each and every conceivable kind of call that can be made by making use of the system. Because it describes the calls that can be made through the system and because it explains the calls that can be made through the system, it is pertinent to the environment of the call center where it is utilized because it explains the calls that can be made through the system. It is related to the phone call that the system is currently processing at this precise time as a component of its investigation of the current scenario. These identifiers are unique to each and every one of the aforementioned sorts of phone conversations, and they in no way, shape, or form apply to any other type of calls whatsoever (Kumar, 2022).

In each queue, randomization is utilized to help create the order in which incoming calls are processed in each queue over the duration of time spans that can span several years. These time spans can range anywhere from a few months to several years. These periods of time could last anywhere from a few months to a few years or even longer. These stretches of time could extend anywhere from a couple of months to a couple of years or even longer in some cases. These intervals of time could last anywhere from a few weeks to a few years or even longer in some circumstances. In some instances, they could even go on for even longer. These stretches of time could run anywhere from a few weeks to a few years or even longer in certain situations. The exact length of these epochs was not always clear. In certain circumstances, they might possibly continue for an even greater length of time (Kumar, 2019).

Depending on the specifics of the situation, the time that has passed since this event could be as little as a few months or as much as several decades. It is challenging to hazard a guess in the absence of additional facts. These periods of time could run anywhere from a few weeks to a few years or even longer in certain situations. In other cases, the length of this time could even be longer. In other circumstances, they might even continue for a longer period of time (Kumwilaisak, *et al.*, 2022).

There were times when it was unclear how long each of these epochs had actually been in existence. There are some circumstances in which there is a chance that they will continue for an even longer period of time than they have so far. This strategy ultimately results in the construction of this order within each queue as a direct consequence of the randomization that is used in the operation that is now being carried out in each queue. This order is constructed as a direct consequence of the randomization that is used in the operation that is now being carried out in each queue (Butler, 2020).

It is common procedure for contact centers that are tasked with the delivery of customer support to always have a significant crew present. This is done in order to ensure that customers receive adequate assistance. This is done in order to provide superior assistance to the company's clients. The vast majority of the time, it is the obligation of these workers to make phone calls to a wide variety of locations that are dispersed across the entire planet. These calls can be placed to anybody or anything, beginning with a single individual and progressing all the way up to a whole nation. As soon as a company takes a call, the call is referred to as a "inbound call," and the receptionist will file it away in the correct folder as soon as the company receives the call. It is common practice for businesses to engage in activities such as telemarketing or debt collection, and as part of those activities, it is also common practice for those businesses to make calls in a proactive manner (Li, 2022).

It's possible that this is the case with other kinds of commercial endeavors as well. The following are some further examples of activities that fall under this category: The use of automated calling systems and the practice of making cold calls are two examples of operations that are carried out more regularly and are classified as being under this category. The term "commercial activity" encompasses a broad range of endeavors, each of which can be thought of as a subset of the larger whole. Some examples of these subsets are telemarketing and debt collecting (Mehrotra, 2019).

Customers have the option of selecting any of these two communication channels with the company as their preferred manner of engaging with the company. Alternatively stated: Customers have the option of communicating with the firm through any of the two

channels of communication that are now available to them. This is done in an effort to make the customers' interactions with the company as uncomplicated and easy to understand as is humanly possible.

Each phone call, as well as the work (data entry, documentation, research, and so on) that agents are obliged to undertake after the call has completed, has a duration that is fully arbitrary. This applies to both the length of the call itself as well as the labor. This holds true not only for the activity, but also for the call itself. This refers to the total amount of time spent on the call itself as well as the amount of work that must be completed. This is true not only for the endeavor in and of itself but also for the call that was issued (Murthy, 2019).

In addition to the amount of work that needs to be completed, this is a reference to the total amount of time that was spent on the call itself. This holds true not only for the endeavor in and of itself but also for the call that was placed out there. Not only does this ring true for the undertaking, but it also holds true for the call. This is a reference to the total length of time that was spent on the call itself, in addition to the amount of work that has to be performed, which is what is being referred to here. This is a reference to the quantity of work that needs to be completed. This is not only true for the endeavour in and of itself, but also for the call that was put out there, thus it is important to keep this in mind. Not only does this ring true for the undertaking, but it also chimes in with the decision that was ultimately taken (Nina-Mollinedo, 2022).

What is being alluded to here is not only the amount of time that was spent on the call itself, but also the amount of work that still needs to be done. This is a reference to the total amount of time that was spent on the call itself, which can be found in the previous sentence. This makes a reference to the quantity of work that needs to be done at this particular point in time. It is necessary that this truth be kept in mind because it is applicable not only to the endeavor in and of itself but also to the call that was made public. It is important that this reality be kept in mind since it applies to the endeavor in and of itself. Not only does this ring true for the initiative, but it also chimes in with the decision that was finally taken. This is an excellent example of how the two are connected (Rowe, 2019).

This is a great illustration of how the two are connected to one another. In this particular instance, not only is the length of time that was spent on the call itself being alluded to, but also the amount of work that has not yet been completed is being referred to as well. The quantity of work that needs to be completed at this particular instant in time is discussed in the preceding sentence, and this is a reference to that sentence. This makes a reference to the total length of time that was spent on the call itself, which was mentioned in the statement that came before this one. It is of the highest importance that this fact be kept in mind since it is relevant not only to the endeavor in and of itself but also to the appeal that was made out to the general public. Keeping this truth in mind is of the utmost importance (Sencer, 2019).

This fact should be kept in mind at all times because it is of the utmost significance. This holds true not only for the effort that is being made but also for the request that is being made right at this very minute. These two statements are consistent with one another. This makes a reference not only to the amount of time that will be used by the call itself, but it also makes a reference to the events that will occur inside the boundaries of that period of time. Specifically, this makes a reference to the amount of time that will be used by the call itself. In other words, we are dealing with a case of double reference here. Read it carefully and pay attention to what it has to say at the same time because it makes a reference to the total amount of time that the call itself will take up (BasarirOzel, 2021).

Therefore, pay special attention to what it has to say because it makes a reference to the overall length of time that the call itself will take up. The total amount of time that the call itself will consume in its entirety throughout the course of its duration has been broken down into its component components and is listed below in an effort to make everything more apparent. This was done in an effort to make everything clearer. As an additional point of clarification, the total amount of time that was spent on the call was given in the form of a number of minutes. This is something that is pertinent not only to the action that has to be carried out, but also to the telephone call that needs to be made. Both of these things are related in some way.

It is essential that this regulation be followed at all times and in each and every one of the situations described above (Sienes, 2022).

There is absolutely no space for bargaining regarding this prerequisite. The applicability of this rule does not include any exemptions of any kind. This is a rule that must be followed at all times and in all circumstances. There are no exceptions. There are no exemptions to this rule. Regardless of the nature of the exceptions that are being sought, the rule's scope of application does not allow for any exclusions to be granted in any circumstance. Regardless of the nature of the exceptions that are being sought, the rule's scope of application does not allow for any exclusions to be granted in any circumstance. This is pertinent not only to the entire length of time that has been

spent on the call, but also to the activity that is being carried out specifically at this present instant in time and at no other time (Singh, *et al.*, 2021).

Incoming calls can be routed to agents, groups, and/or places by making use of technologies such as Computer Telephony Interaction, which is more commonly abbreviated as "CTI." This can be accomplished in a variety of various ways depending on the situation. Automatic Call Distribution is an extra option that can be taken into consideration. CTI stands for "Computer Telephony Interaction," but its full name is "Computer Telephony Interaction." CTI is an abbreviation for "Computer Telephony Interaction" (sometimes abbreviated as "ACD"). When taken together, these two abbreviations make reference to the same idea when considered in conjunction with one another (abbreviated as "ACD"). These technologies are always being improved, and at some **point,** in the **not-too-distant** future, they will be able to support a level of thinking that is significantly more advanced than it was previously capable of being supported by them. This will be a significant leap forward from where they were previously capable of supporting thinking (Smith, 2021).

When compared to what they were previously capable of supporting in terms of thinking, this will be a significant leap forward. Incoming phone calls that are received by one of these devices have the capacity of being routed to particular agents, groups, or locations based on the preferences of the person who is using the device. These preferences can be set by the person who is using the device (Mehrotra &Fama, 2003). It is possible to educate a number of agents to manage either a single form of call, a number of separate types of calls, or all types of calls by using a range of call handling strategies. This is possible since there are many different types of calls. This can be accomplished by applying a singular method to all different kinds of phone conversations (Taylor, *et al.*, 2021).

This instruction can be given to each of the agents one at a time, or it can be given to all of them at the same time. It is feasible for you to issue this command to a big number of agents all at once in a single, consolidated action if that is something you would like to do. Each agent has the capability to learn how to handle a certain type of call, and each agent has the potential to establish their own one-of-a-kind set of priorities and preferences surrounding the technique in which they handle calls (Tsai, *et al.*, 2022).

A. Evolution of call centers

According to the findings of the research that was carried out by Rowe, Marciniak, and Clergeau, call centers, or CCs as they are more often known, "are typically believed to be a hotbed for testing new information technology" (2011). Not only do technologies of this kind play an important part in the delivery of exceptional customer service across all industries, but they also assist to alleviate tension within the framework of the CC environment. CC environments are notorious for their high levels of stress. The surroundings at CC are well-known for the high levels of stress they contain (Cleveland, *et al.*, 2019).

It is common knowledge that the business of providing customer service is one of the most cutthroat and competitive sectors in any region on the entire planet. This is true regardless of where you are located. It makes no difference where you reside; this is always the case. The most important factor in determining how much of an improvement can be made to an organization's overall customer experience is the effectiveness with which it recruits new customers, maintains relationships with existing ones, and satisfies existing clientele (Deng, 2022).

This can be accomplished by the organization's ability to satisfy existing clientele. This relates to the degree to which the business is able to satisfy the requirements of the customers it already has. If the company is effective in satisfying the requirements of its existing clientele, then it will be able to accomplish this goal. This pertains to the degree to which the organization is able to live up to the requirements set out by the customers that it already possesses. This target will be accomplished for the company if it is effective in satisfying the requirements of the customers it already has, which is a prerequisite for accomplishing the goal (Gans, 2020).

This is as a result of the fact that the level of efficiency with which existing communication channels are utilized is the single most essential element in determining the amount of room there is for future development.

Previous research has investigated both the part that technology played in the growth of CCs as well as the way in which technology enables new organizational forms. Specifically, the function that technology played in the growth of CCs was investigated. According to the findings of these investigations, technology played a big role in each of these areas (Golembiewski, 2018).

It has been determined through the course of these research that technology is involved in both of these facets. On the other hand, there is not a significant amount of research that is primarily focused on the advancement of technology in CCs. This is a limitation of the field. This is one of the constraints placed on the field. This creates a significant obstacle in the way of progress. It gave an insight of the past by studying and analyzing data, and it

generated predictions about the future on the rate at which new technologies evolved and ultimately impacted CC operations. This research made use of a process that is referred to as historical research. The method of looking into significant events that have place in the past is one of the options that is being considered here (Kumar, 2022).

In addition, call centers, which are an essential component of the entire experience a customer has with a company, use technology to standardize, streamline, and uniformly provide service across multiple contact channels (such as voice, fax, e-mail, and the Internet), regardless of whether they are operating in a single network call queue or multiple call queues. This is the case regardless of whether the call center is operating in a single network call queue or multiple call queues. This is the situation regardless of whether the call center is working in a single network call queue or many call queues at the same time (Kumar, 2019).

It makes no difference whether the call center is functioning in a single network call queue or several call queues at the same time; this is the situation regardless of which. This is the condition regardless of whether the call center is operating in a single network call queue or numerous call queues at the same time; it makes no difference either way. In this sense, it makes no difference whether the call center makes use of a single network call queue or a number of distinct call queues. In this regard, it is irrelevant whether the call center makes use of a single network call queue or a number of separate call queues. Either way, the call center must deal with incoming calls in some fashion (Kumwilaisak, *et al.*, 2022).

This phase is completed even if the call center is operating in a single network call queue or in a number of call queues at the same time. It makes no difference. It is carried out in a manner that is distinct from the method used in the other instances. It is unrelated to the topic that is being discussed at the present time for a number of reasons. In addition, the credit card industry is continuing its rapid expansion in an effort to maintain the availability of entry-level jobs, provide customer support that goes beyond the use of the telephone, influence businesses, and achieve economic benefits. All of these goals are being pursued with the intention of achieving economic benefits (Butler, 2020).

These goals are being pursued simultaneously one after the other in a sequential order. In the meantime, we are making every effort to achieve each and every one of these goals by using every resource at our disposal. The fundamental purpose of contact centers is to manage the processing of exceptionally high quantities of service requests that are received by telephone. These requests can come from a variety of different customers. To be more explicit, the duty of responding to these enquiries belongs to call or customer service centers known as contact centers. In addition, call centers that provide customer service have broadened the range of activities that fall within their purview to include contact services in addition to the processing of phone calls. This is done in an effort to bring in a greater number of clients (Li, 2022).

In the past, their primary task was to answer any and all calls that were placed to the company. In addition to taking care of the customers' telephone calls, the customer contact services at issue are also tasked with managing the customers' written correspondence, including e-mail, faxes, and other forms of electronic mail. Synchronous online chats are an additional feature that certain contact centers offer to their clientele as a supplementary perk of their business (Mehrotra, 2019).

This is done since it makes it simpler for call centers to better satisfy the wants of their customers by utilizing the information gained from this practice. In addition, CCs provide additional services through a wide variety of alternate modes of service delivery, which may be accessible in a variety of different ways. These services can be utilized in a variety of settings. These services are adaptable, and can be used in a range of different environments. These services are sufficiently adaptable to be utilized in a broad variety of distinct contexts and environments. Because of the adaptability of these services, they can be employed in a wide number of settings, which contributes to the overall versatility of these services (Murthy, 2019).

B. Web-based call centers

Over the course of the past few years, there has been a discernible increase in the significance of contact centers that are run through the utilization of the internet. Over the course of the last few years, this trend has become much more obvious. Customers have the capacity to communicate with customer service representatives by using the internet, which provides them with access to contact centers that they may use to establish communication with the experts that provide customer service. These call centers are able to effectively manage communications with customers, which is a factor that plays an essential role in achieving customer satisfaction and loyalty (Nina-Mollinedo, 2022).

Both of these endeavors need effectively managing their communications with their respective customers. Many smaller businesses make the decision to outsource their customer care and support services to third-party contact

centers because they do not have the financial or labor resources necessary to construct and staff a fully owned and operated call center. These resources include both financial and labor resources. This is because they are unable to fulfill all of the requests that have been made for their services (Rowe, 2019).

This takes place rather regularly as a direct result of the fact that they do not have adequate people. This is because they are unable to successfully compete with businesses that are more well-established and larger in size. This is the primary reason behind this. When it comes to assisting customers in a digital environment, like the one we are currently examining, situations similar to the one we are currently examining occur rather frequently. This is due to the characteristics of the media itself. On the other hand, in the vast majority of cases, managers are reluctant to outsource the communication management responsibilities for which they are responsible to contact centers that also provide their services to the managers' competitors (Sencer, 2019).

This is due to the fact that contact centers provide their services to the managers' competitors. This is due to the fact that the contact centers are tasked with handling the communication of the competitors of the managers. This is due to the fact that there is a concern that confidential information may be disclosed to the general public if the responsibilities of management were delegated to independent call centers. The possibility that private information could be viewed by members of the wider public is the source of this worry (BasarirOzel, 2021).

By entering into exclusive contracts with retailers in each product category, call centers that are owned and run independently may be able to mitigate the negative effects of this risk. Because of this, independent call centers will need to have customers who use a variety of product categories, despite the fact that it is more efficient for them to select items that allow them to keep operational synergies. This is the case even though it is more efficient for them to select items that allow them to keep operational synergies. This is the case despite the fact that it would be more beneficial for them to choose things that would enable them to maintain operational synergies (Sienes, 2022).

This is the case in spite of the fact that it would be more advantageous for them to make decisions that would enable them to keep operational synergies, which they are unable to do. This is the situation despite the fact that it would be more beneficial for them to make decisions that would enable them to retain operational synergies, which they are unable to achieve. This is the case despite the fact that they are unable to do so. Despite the fact that it would be more advantageous for them to make decisions that would enable them to retain operational synergies, which is something that they are unable to accomplish, this is the situation that has arisen (Singh, *et al.*, 2021).

Despite the fact that they are unable to carry out the action, this is nonetheless the situation. This circumstance has developed despite the fact that it would be more advantageous for them to make judgments that would enable them to retain operational synergies, which is something that they are unable to accomplish. Nevertheless, this is the situation that has come about. The circumstance remains the same, despite the fact that they are unable to carry out the action in question. Over the course of the past few years, there has been a discernible increase in the significance of contact centers that are run through the utilization of the internet. Over the course of the last few years, this trend has become much more obvious. Customers have the capacity to communicate with customer service representatives by using the internet, which provides them with access to contact centers that they may use to establish communication with the experts that provide customer service (Smith, 2021).

These call centers are able to effectively manage communications with customers, which is a factor that plays an essential role in achieving customer satisfaction and loyalty. Both of these endeavors need effectively managing their communications with their respective customers. Many smaller businesses make the decision to outsource their customer care and support services to third-party contact centers because they do not have the financial or labor resources necessary to construct and staff a fully owned and operated call center (Taylor, *et al.*, 2021).

These resources include both financial and labor resources. This is because they are unable to fulfill all of the requests that have been made for their services. This takes place rather regularly as a direct result of the fact that they do not have adequate people. This is because they are unable to successfully compete with businesses that are more well-established and larger in size. This is the primary reason behind this. When it comes to assisting customers in a digital environment, like the one we are currently examining, situations similar to the one we are currently examining occur rather frequently. This is due to the characteristics of the media itself. On the other hand, managers frequently display reluctance when it comes to outsourcing the communication management responsibilities for which they are responsible to contact centers that also provide their services to the managers' competitors. This is because the managers' competitors

could potentially benefit from the contact centers' services. This is due to the fact that the managers' rivals may be able to get an advantage from the services provided by the contact centers. This is due to the fact that there is a worry that the confidential information may be disclosed to unauthorized parties if these obligations are outsourced (Tsai, *et al.*, 2022).

This is the basis for our concerns in this regard. By entering into exclusive contracts with retailers in each product category, call centers that are owned and run independently may be able to mitigate the negative effects of this risk. Despite the fact that it is more efficient for them to select items that allow them to keep operational synergies, independent call centers will need to have customers who use a variety of product categories because of this. This is the case even though it is more efficient for them to select items that allow them to keep operational synergies. This is the case in spite of the fact that it would be more advantageous for them to make decisions that would enable them to keep operational synergies, which they are unable to do (Zhang, *et al.*, 2022).

This is the situation despite the fact that it would be more beneficial for them to make decisions that would enable them to retain operational synergies, which they are unable to achieve. This is the case despite the fact that they are unable to do so. Despite the fact that it would be more advantageous for them to make decisions that would enable them to retain operational synergies, which is something that they are unable to accomplish, this is the situation that has arisen. Despite the fact that they are unable to carry out the action, this is nonetheless the situation. Even if it were to be to their advantage to make decisions that would allow them to keep operational synergies even if they chose items that would inhibit those efforts, this is not the case (Aksin, *et al.*, 2020).

Even if it were to be to their advantage, it would not be to their advantage to make decisions that would enable them to keep operational synergies. It would be in their best advantage to make decisions that would allow them to maintain the synergies that result from their operations. This is not the case, despite the fact that it would be to their advantage to make decisions that would enable them to keep operational synergies, which they are currently unable to do (Bhatnagar, 2004).Access to the internet is currently the most important piece of technology for the delivery of electronic government services, and governments all over the world are making significant efforts to increase the number of people who are connected to the internet in their respective countries in order to meet the growing demand for these services (Ang, 2019).

In addition to offering a variety of monetary subsidies and incentives, they are achieving this objective by installing public Internet kiosks in a wide variety of public venues, such as libraries, shopping malls, and other areas that are comparable to these kinds of establishments. In addition to that, they are providing a wide range of additional monetary perks and incentives (Bhatnagar, 2021).

However, the number of people who have access to the internet is a significant issue that acts as a limitation not only on the popularity of the internet but also on the ways that it is utilized. This is a significant issue that acts as a limitation not only on the popularity of the internet but also on the ways that it is utilized. This is a significant problem that acts as a barrier not just to the widespread adoption of the internet but also to the various applications of it that are now in use. This presents a difficulty due to the fact that there is a certain number of people who can connect to the internet at any one moment, which acts as a limiting factor. There were only 863 million people all across the world who used the internet in the year 2004 (Bhatnagar, 2021).

Since then, those Fig.s have seen a dramatic increase. Since then, that Fig. has increased by a substantial amount since it was originally announced to the public. By a wide margin, the most typical approach to get access to information is through the utilization of a telephone. This is especially apparent when contrasted with the usage of the internet in this setting, where internet usage is quite infrequent. In 2004, it was predicted that there would be 1207 million users of fixed line services; nevertheless, there were 1758 million members of mobile service providers. This discrepancy was due to the fact that more people opted to utilize mobile services (Charoensukmongkol, *et al.*, 2022).

This disparity was caused by the fact that a greater number of people choose to make use of mobile services. When the data were gathered in the 1990s, mobile service providers had just begun to expand their network coverage, which is why there is such a gap between the two sets of results.In addition, the number of people who use the internet is not distributed evenly across the population in any way that can even be compared to a distribution that is even slightly similar to an even distribution (Cleveland, *et al.*, 2019).

This is the case in any way that can even be compared to a distribution that is even slightly similar to an even distribution. In 2004, just 7.23 percent of the population in China had access to the internet. In comparison, this ratio was at 63.3 percent in the United States and 65.28 percent in Australia. In this regard, China's performance lags well

below that of other countries that are considered prosperous. When the number of individuals who use mobile phones in developed countries and industrialized countries are compared, it becomes apparent that the gap between the two is not quite as big as it might at first appear to be. As a direct consequence of this, almost every single household in the modern world, and particularly those in emerging nations like China, now has access to a cell phone. One nation that exhibits this concept in a manner that is quite straightforward is China (Deng, 2022).

Despite this, governments in every region of the world are rapidly becoming significantly more dependent on the Internet as their principal platform for the provision of electronic government services to the people living in each of their distinct locations. It is not unreasonable to suppose that this trend will continue into the unknowably far future. It is imperative that governments take the necessary precautions to assure that the integrity of the public finance system will not be compromised by electronic government projects. It is also imperative that governments take the necessary precautions to ensure that the public finance system will not be compromised (Gans, 2020).

In addition, it is of the utmost importance that governments implement the appropriate safety measures to guarantee that the integrity of the public finance system will not be jeopardized. In addition, it is of the utmost importance that governments implement the required safety measures to guarantee that the integrity of the public finance system will not be threatened. This is because the integrity of the public finance system is vitally important (Golembiewski, 2018).

It is of the utmost importance that governments put into effect the required measures for the safety of the general population in their respective countries. The singular dependence on the Internet that is being utilized in the process of putting into practice e-governance is being done so with the intention of enticing the greatest possible number of people, which is the incentive behind the use of the Internet in this manner. This is being done so in order to put into practice e-governance. On the other hand, given that this cannot be guaranteed to lead to an improvement in the overall quality of the service, there is no certainty that this will lead to such an improvement (Kumar, 2022).

It is possible that efforts to improve the general quality of the service may be hampered as a result of this because it places a significant amount of responsibility on the shoulders of the typical citizen. This is because it places a significant amount of responsibility squarely on their shoulders, which is the only place it can be placed. This is because the vast bulk of the duty is placed squarely on the shoulders of the average citizen. The reason for this is due to the fact that the vast majority of the responsibility is placed on them. As a consequence of the divide, individuals who are considered to be on the "have not" side of the digital divide will be unable to access the official websites of the various levels of government (Kumar, 2019).

This is because the websites are password protected. On these websites, the general public can always read over the most recent instructions, regulations, and guidelines that have been posted. Instead of communicating with citizens through traditional types of media like newspapers, televisions, and other comparable forms of media, this would be done instead (Kumwilaisak, *et al.*, 2022).

(Buffa et al., 1976) Developed an integrated work shift scheduling system, which was then employed by the General Telephone Company of California for the purpose of scheduling 2,600 telephone operators across 43 different sites. This system was integrated into the work shift scheduling process. The process of arranging work shifts was updated to include the addition of this technology. The system required that a prediction of incoming calls be created every half an hour, that call volume be turned into operator requirements, that tours be scheduled making use of a heuristic technique, that operators be assigned to tours, and that the system be executed (Butler, 2020).

III. METHODOLOGY

In this section, the methods that are used for the design and implementation of the project. The methodology in divided into sections.

A. Linux virtual machine

A virtual machine (VM)is a term that is used in the world of information technology to refer to the virtualization or emulation of a computer system. The capabilities of a real computer can be simulated on a computer network using "virtual machines," which are designed to look like actual computers (Aksin, *et al.*, 2020).

It is probable that their implementations will necessitate the use of specialized software, hardware, or possibly even a combination of the two. The computer used was running a windows operating system so a VM had to be used to emulate the LINUX operating system. This is because PBX works very well with Linux and not windows.

B. PBX simulation

The phrase "Private Branch Exchange" is sometimes shortened to "PBX," which is an acronym that stands for

the longer form of the phrase. This practice has become widespread. "PBX" is the abbreviation that's used while talking about "private branch exchange." In accordance with the standard operating procedure, the total amount of time will be decreased in half. Phone conversations between users of a PBX system can take place in both directions thanks to the system's internal lines, which enable users to connect with one another and support two-way discussions (Ang, 2019).

These lines also make it possible for users to have conversations with one another over the phone. Users are also able to have phone conversations with one another via these lines, which was not previously possible. Through these lines, users can now engage in phone conversations with one another, which was not previously feasible. Users are able to communicate verbally with one another and even carry on phone conversations with one another as a direct result of these lines. In addition to that, they could also phone one another.

Users of the PBX phone system are able to simultaneously make and receive calls from and to the outside world while also using the system. These calls can come in from any location in the world. These calls can be received from anywhere in the world, and they can also be directed to any destination on the planet. This is something that is feasible to do given that the system supports three-way calling. There is a good chance that these phone calls originated from any one of the countries that are physically located on this globe. It is not feasible to state with absolute certainty where they originated (Bhatnagar, 2021).

These phone calls may have come from any one of the countries that are physically located on this globe; there is a fair likelihood that they came from somewhere on this planet. There is no way to know with complete confidence where they came from because it is not possible. Call forwarding, call transfer, call queue, auto-attendant, and voicemail are only some of the business telephony services that may typically be provided by a PBX phone system. Other services that can be provided include voicemail and auto-attendant (Bhatnagar, 2021).

Customers of a company can receive these services if the company utilizes a PBX phone system in its operations. This is because PBX phone systems allow for a greater degree of flexibility and control over the manner in which calls are managed, which is the primary reason for this benefit. This is due to the fact that PBX phone systems were built to manage several calls at the same time, which is the reason why it is possible for them to handle so many calls at once. The supply of telecommunication services to these customers is an expansion of the services that are already offered to those clients, which presents an opportunity for commercial organizations, as it would represent an increase in the number of customers served (Charoensukmongkol, *et al.*, 2022).

This is due to the fact that PBX phone systems are able to perform a huge number of tasks all at once, which is the reason why the situation is not impossible. In other words, the possibility of the event occurring is due to the ability that was mentioned earlier. The operation of PBX systems can be carried out by making use of a large number of various communication methods, such as conventional analog or digital telephone lines, in addition to Voice over Internet Protocol (VoIP), which is a relatively recent development (VoIP). The utilization of digital telephone lines is yet another method that is capable of being implemented. The use of digital telephone lines is yet another option that can be used, and this one can also be used. Additionally, this one is a possibility (Cleveland, *et al.*, 2019).

Voice over Internet Protocol, more commonly referred to more frequently as VoIP, is an additional choice that might possibly be employed in place of an alternative. VoIP is typically known more frequently as VoIP. If you did not have a PBX phone system, you would not be able to have as many telephones at your place of business as you would like to have there. This would prevent you from making as many calls as you would like. Because of this, you won't be able to utilize your room to its full potential. Because of this, you will not be able to accomplish as much as you are capable of in terms of productivity (Deng, 2022).

This restriction applies to both traditional landlines and mobile cellular phones in their mobile forms. Landlines are considered to be mobile phones. On the other side, you only need one of them in order to have as many of them as you require in order to meet your requirements, so there is no need to worry about running out. In order for you to be successful in achieving this objective, the one and only physical phone line that is now tied to the site where your firm is located will need to be severed. After the completion of this step, a sizeable number of lines will be able to be positioned in their appropriate locations. It is now feasible, as a result of this, to provide service to several customers at the same time, which is helpful not only for the business but also for the customers themselves (Gans, 2020).

After that, particular telephones can be connected to each of these lines by applying the right adapters that are necessary for the job. This can be accomplished by following the steps outlined above. A technician would be

able to carry this out successfully. To achieve this objective, all that is required is the application of the adapters that are designed specifically for the task at hand. In order to do this task, it is sufficient to check the instructions that were included with the adapters in the particular packaging that they came in. Because the service does not charge its customers for any of the calls that they make to one another while they are using it, the circumstances that are currently taking place are an even more desirable one to be in than they would otherwise be if the service did not provide this benefit. In other words, if the service did not offer this benefit, the circumstances would be less desirable (Golembiewski, 2018).

It was chosen to put into action the voice over IP PBX technology in order to boost the possibility of the application's being able to properly complete the requirements being asked of it. This is the most compelling illustration that could possibly be utilized. In recent years, the conventional private branch exchange, also known as a PBX, has been undergoing a process of modernization, which has resulted in the emergence of the more cutting-edge VoIP or IP PBX. This development came about as a result of the convergence of several technological advancements. The development of new technologies was directly responsible for the occurrence of this shift. This is because both "VoIP" and "IP PBX" are abbreviations that stand for "voice over Internet Protocol," which is the explanation for why this is the case (Kumar, 2022).

The increase in technological capability that has taken place over the course of the past few years is directly responsible for this shift in behavior. Even though it is capable of doing the same activities as a traditional PBX, it also offers a great degree of functionality that is not included in traditional PBXs. This is in addition to the fact that it is capable of doing the same activities as a regular PBX. This is in addition to the fact that it is able to do the same functions that a traditional PBX would. It is able to carry out a variety of tasks that are not possible with standard PBXs since it includes functionality that enables it to do so (Kumar, 2019).

These jobs include: In addition to this, it possesses the significant advantage of being able to carry out the same functions as a conventional PBX, which is a benefit that cannot be overlooked. Because of the capabilities that it provides, it is able to carry out a wide variety of operations that are not possible to carry out with regular PBXs. These operations include: Standard PBXs are insufficient for doing these tasks in their whole. These professions include the following: Because it possesses this quality, it is able to carry out the same acts as, which is a consequence of the fact that it possesses this quality. Because of its enhanced capacity, which makes it possible for it to do so, it is able to carry out a far larger variety of tasks than traditional PBXs are able to carry out. This is because its capacity has been raised.

This is due to the fact that typical PBXs have restricted capabilities in this regard. In addition to this, there is a possibility that the costs involved with this alternative approach may turn out to be lower than what was initially anticipated in terms of the total amount of money that will be spent on it. This is because there is a possibility that the total amount of money that will be spent on it will be lower than what was initially anticipated. This is due to the fact that there is a chance that the overall sum of money that will be spent on it will be significantly less than what was first projected to be spent on it. This is because there is a possibility that the overall sum of money that will be spent on it will be a considerable amount less than what was initially predicted to be spent on it (Kumwilaisak, *et al.*, 2022).

IP PBX systems, as opposed to more conventional phone lines, make use of the Internet protocol in their communication processes. This is in contrast to traditional phone lines. In comparison to the conventional phone lines, this is an advantage. This is a benefit in compared to the traditional phone lines that are available. In comparison to the conventional phone lines that are offered, this is an advantage that may be taken advantage of. This is an advantage that can be used to one's advantage in comparison to the traditional phone lines that are currently being made available. In compared to the traditional phone lines that are currently being made available, this is an advantage that can work to an individual's benefit and can be exploited to one's advantage (Butler, 2020).

This is an advantage that can work to an individual's benefit and can be leveraged to one's advantage when contrasted to the traditional phone lines that are currently being made available. This is an advantage that can currently be exploited. Voice is originally transformed into data before being transmitted over the Internet; then, once it has arrived at its final location, the data is ultimately transformed back into voice (Li, 2022).

IV. RESULTS AND FINDS

a. VM installation

The oracle virtual box was used for installation of the virtual machine. The machine was named CALLCENTERBY PACIFIQUE and the server’s name provided.

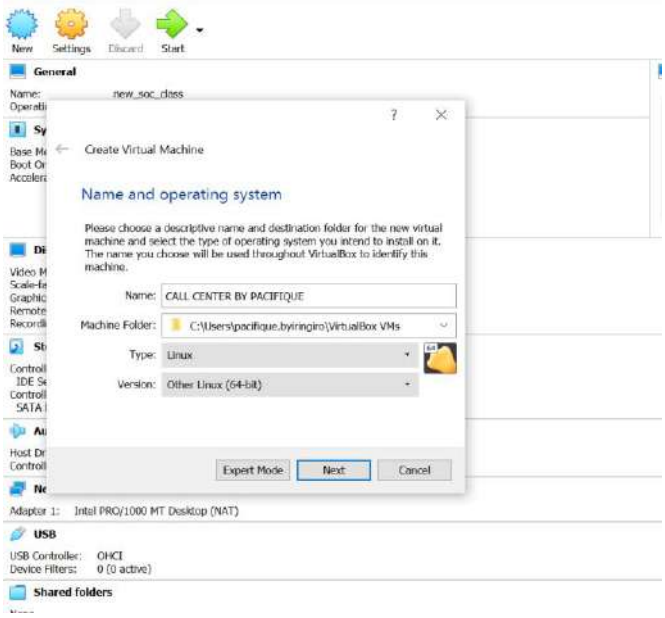

Fig. 1: Operating System Naming

As it can be seen from Fig. 1, the interface helps the user to choose the type of operating system and its version that the user will install. It also helps the user to rename the version machine that is going to be installed.

A memory size (RAM) of 1 GB was chosen.

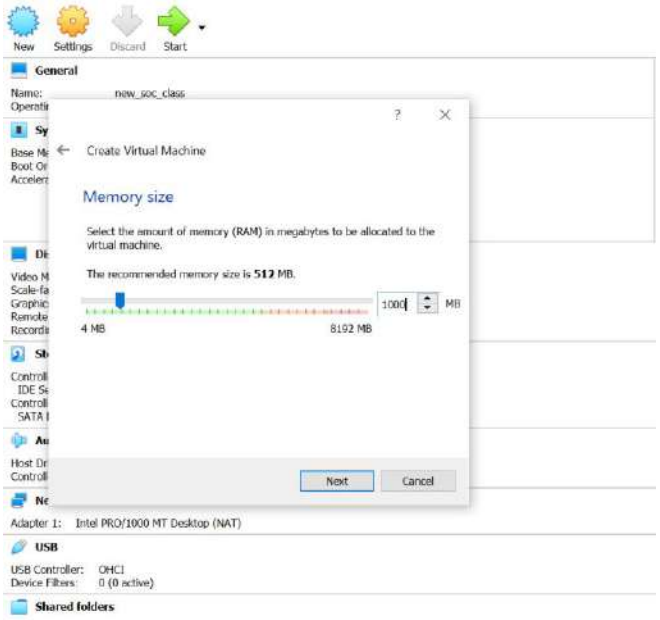

Fig. 2: Memory size allocation

As it can be seen from Fig. two, normally for a computer to have a speed, it needs some resources such as Random Access Memory (RAM). This interface helps to specify the amount of the RAM that a new version machine will use.

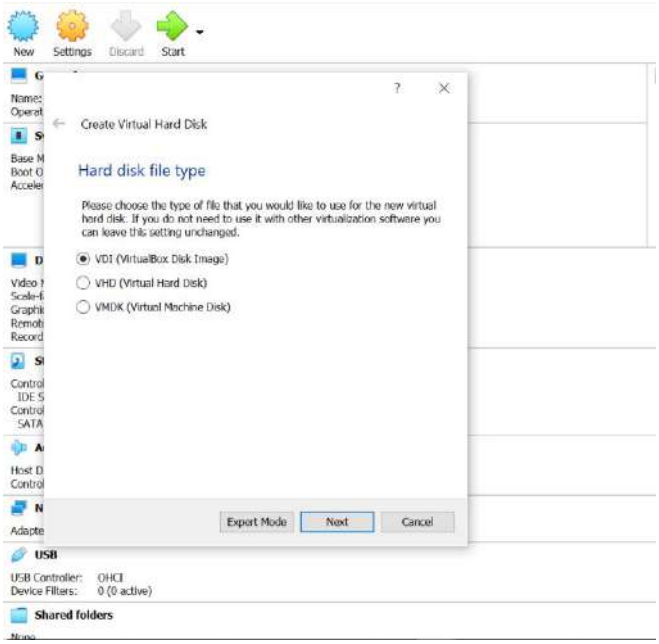

Fig. 3: Hard disk selection

As it can be seen from Fig. three, the virtual box disk image type of hard drive for the VM was chosen. This interface helps to provide different hard disc types that a user will use.

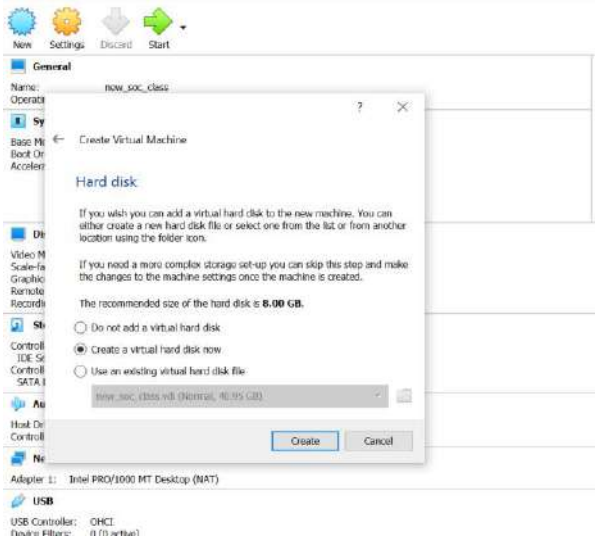

Fig. 4: Hard disk creation

A hard disk size of 20 GB was chosen for storing the data handled by virtual machine. As it can be seen from Fig. four, after deciding hard disc type, now it needed to create it with the help of this interface.

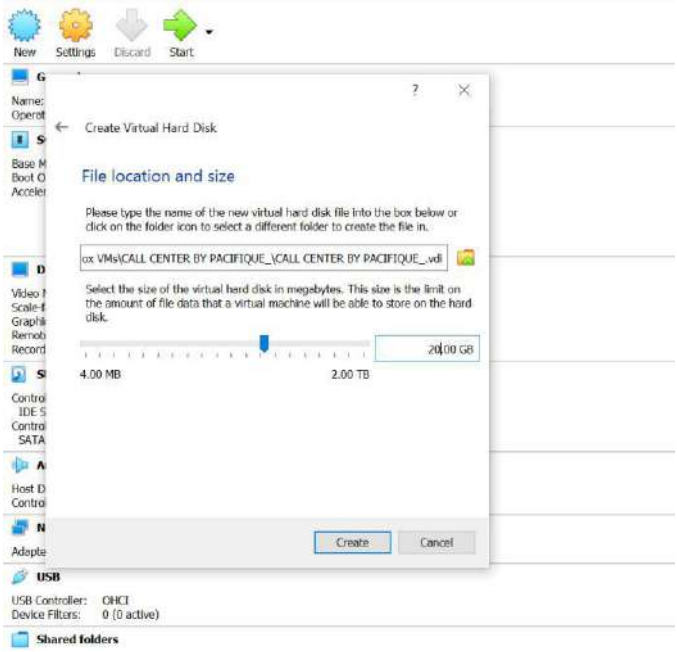

Fig. 5: Hard disk size selection

As it can be seen from Fig. five, the user can adjust the size of the disc, of which the interface shown represents.

The iso file for PBX was then selected for installation.

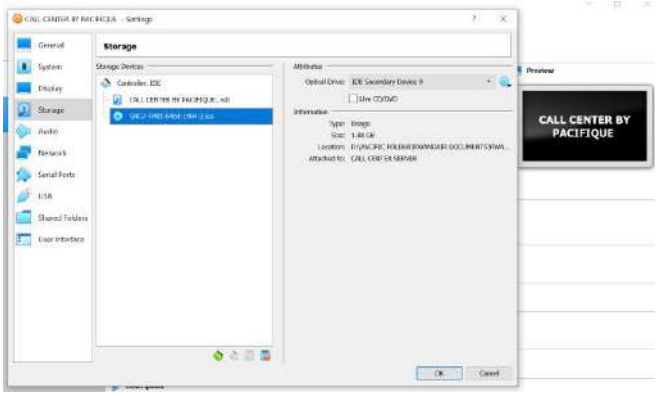

Fig. 6: ISO file selection

Fig. six shows how, once a virtual machine is created, the user can choose the ISO image that contains operating system set-

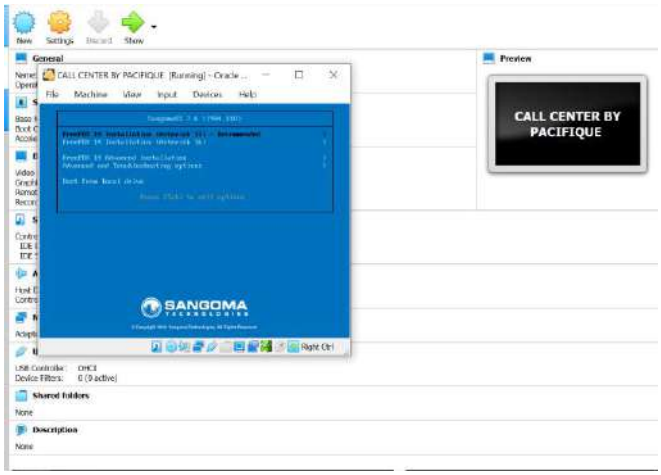

Fig.7: PBX Installation

There are different types of Free PBX set ups. The recommended one is the version Free PBX 14 and Asterisk 14 as shown in Fig. 7.

INSTALLATION IN PROCESS

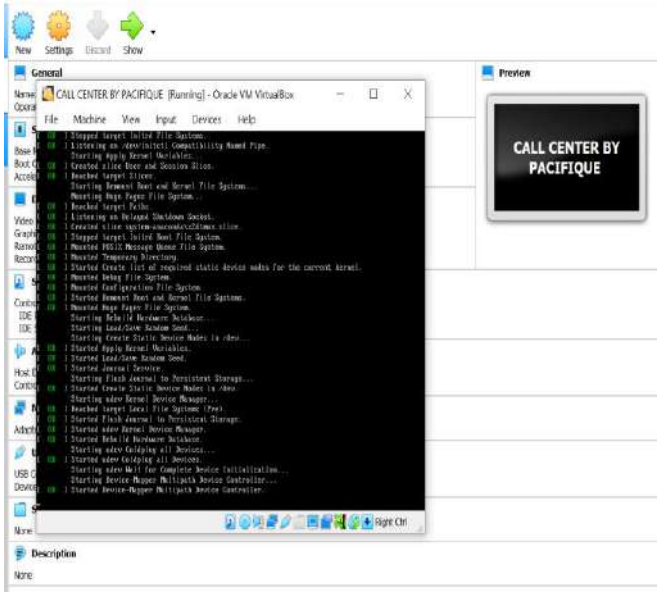

Fig.8: PBX installation process

As it can be seen from Fig. 8, the root password wasset. At this phase, the operating system starts installing installation packages as it can be seen from the Fig. by ‘’ok’’, the installation was successful.

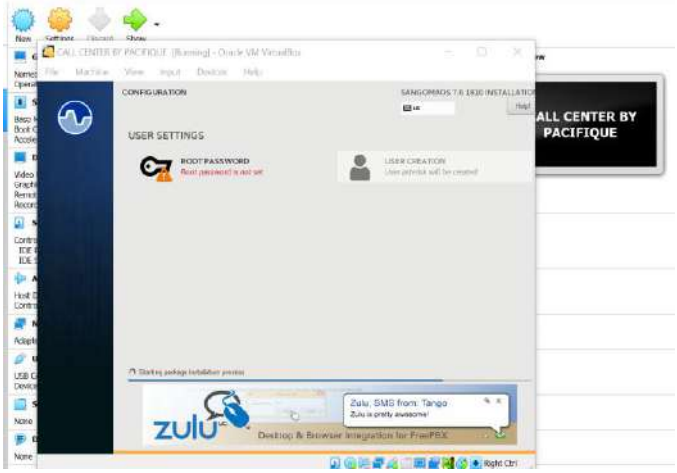

Fig.9: Root password

The system was then restarted for the installation to take effect. For security reasons, it is recommended to set up root password. This means that for any change that requires administrator password, root password will be used.

b. Free PBX activation

In order to use the commercial modules of free PBX, activation and account creation was required. This is illustrated in the steps that follow.

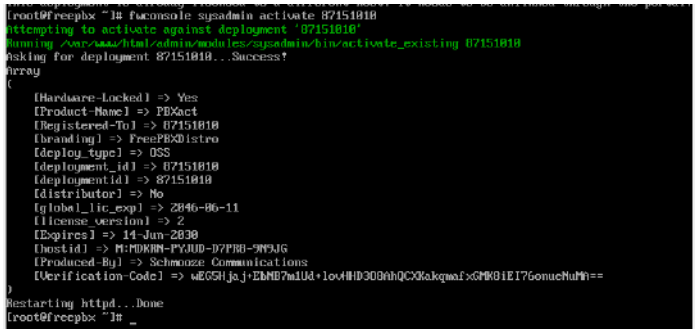

Fig.10: Free PBX activation

The system modules were then updated. Once a free PBX installed, it is needed to activate it to use commercial modules. Some free modules also require free BPX installation such as system admin and others.

Fig.11: Module updates

As it can be seen from Fig. 11, once free PBX is installed, for it to work properly, updates are required to get the deployment ID from which the modules updates are done.

The updates were then run:

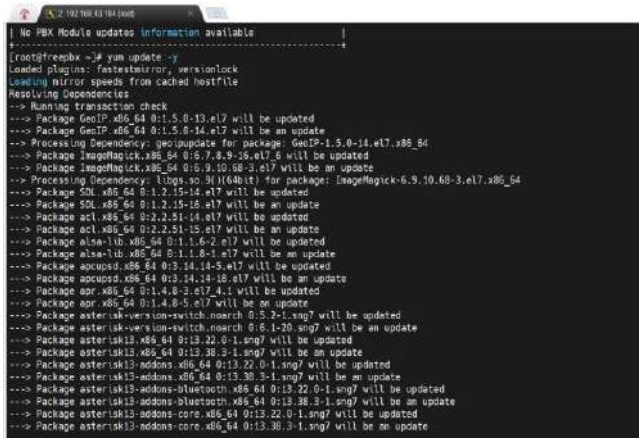

Fig.12: Running updates (first step)

Running updates take some time between thirty minutes to one hour depending on internet speed you are using. Updates are important of any operating system to be able to use latest features. However, it is not recommended to setup automatic updates on PBX server as it may disconnect sometimes the system services without acknowledgement of system administrator. Updating system manually is advisable to truck which updates has been installed and plan for system maintenance depending working schedule.

Fig.13: Running updates (second step)

As it can be seen from Fig. 12 and Fig. 13, for the updates to be running, requires to be connected on internet. It downloads every update package and displays the packages in percentages. Once 100% downloading is achieved. The system extracts the packages for installation.

Fig.14: Restarting services

Once updates are done, the system requires to restart all the services in order to access it again as it can be seen from Fig. 14.

Fig.15: Extension addition

As it can be seen from the Fig. 15, extension needs to be added because it's only the way to identify the person.

Fig.16: Adding a phone

As it can be seen from the Fig. 15, phone number needs to be added because its only the way to identify the person.

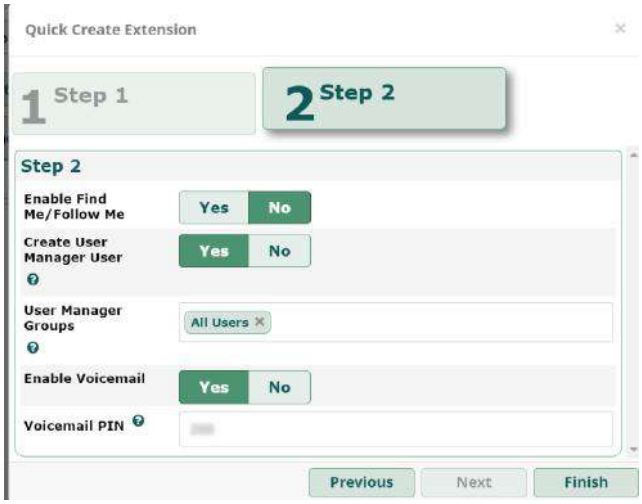

Fig.17: Extension creation

The microSIP virtual extension was added upon the creation of the extension account. As it can be seen from the Fig., a new phone number can be added immediately.

Fig.18: Microsip addition

A virtual desktop extension was made to assign a created extension details in order to communicate with other extensions connected on the same Free PBX sever.

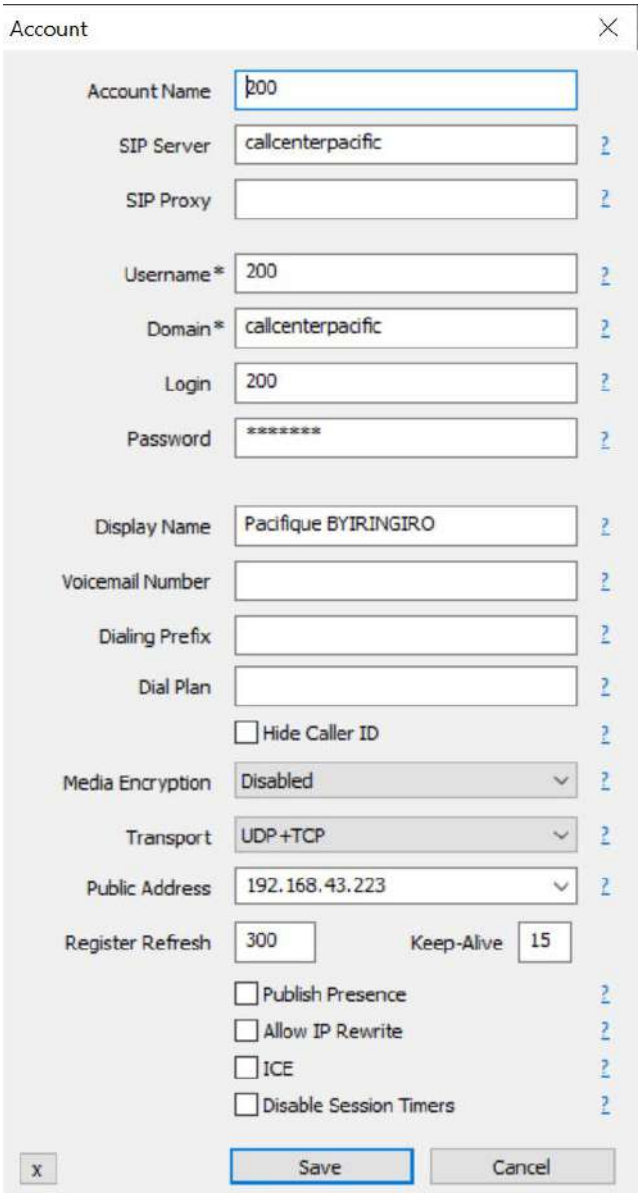

Fig.19: ConFig.d account

As it can be seen from the Fig., the online means that an extension is reaching the free PBX server successfully.

c. Free PBX connection

The Fig. below illustrates how mobile phones connect to the internet via free PBX:

Fig.20: Phone and PBX connection

As it can be seen from the Fig., extension connects to the free PBX server in local area network. If the user plans to use normal phones like MTN, the free PBX server, it is needed to be linked with the VPN server. The phones are linked through a server to a web. When one user makes a call from a phone, the signal is transmitted to the PBX system on the computer. The signal is then relayed to the cloud via the internet. The receiver then sends a response through the same path. Many phones can be connected together through the network to make a call center.

V. CONCLUSION

One of the most significant benefits of hosted PBX is that it enables businesses to save a sizeable portion of the money that would have been spent on the acquisition and upkeep of an on-premises system. This is one of the most significant financial advantages of hosted PBX. Because it is housed in the cloud, the PBX falls under the purview of the customer's service provider when it comes to matters of maintenance and setup. As a direct consequence of this, you won't have to spend any additional money on hardware or maintenance in the near future. This is because this situation has been resolved. The entire cost of the system does, in fact, include enough money to pay for the purchase of each and every one of those separate components. This not only results in cost savings, but it also eliminates the demand for additional IT personnel whose primary task it would be to solve issues of this kind. Because the provider is responsible for handling any issues that may arise with the PBX, this not only results in cost savings, but it also results in cost savings. Since the company does not have to worry about the burden of conducting maintenance or keeping software up to date, they are free to concentrate on the things that are most important to their business without any interruptions. This is a wonderful alternative for start-up businesses as well as enterprises that operate on a scale that is more modest.

A hosted PBX system will often offer a wide variety of services that are helpful to a company in its attempts to improve the quality of its internal communications. These services can be advantageous to an organization in the following ways: A company that uses a system that is hosted in the cloud is able to gain access to a wide variety of helpful services, such as call queuing and recording, call routing and switching, auto attendants, phone menus, conference calls, voicemails, greetings, and conference calls. These services are available to the company because the company is able to gain access to a system that is hosted in the cloud. In addition to that, the company is able

to keep a record of any calls that are placed to the establishment.

The audio quality of a PBX system is ideal for clearer communication, and the capability to record calls, maintain client information, and provide a better communication experience for the customer from the very beginning to the very end is essential for preserving the best practices for successfully conducting business in today's environment. Because of the capabilities provided by PBX phone systems, calls may be directed to anybody, at any time, and via any mobile device. This is true regardless of location (assuming that certain features are applicable). Because of this, critical customers' phone calls will never go unanswered, and staff will be able to connect with one another in a way that is both productive and uninterrupted.

To summarize, a private branch exchange (PBX) phone system is beneficial not just for a company or a call center, but also for the end user of the service. This is because PBX systems allow users to make and receive calls over a private network. PBX systems make it possible for several users to share a single phone line, which is why they are so popular. In this day and age, when consumers expect things to be reasonably quick while also desiring a satisfying experience with the firms, they choose to do business with, providing outstanding communication and customer service is a critical aspect in a company's ability to be successful.

In this day and age, consumers expect things to be reasonably quick while also desiring a satisfying experience with the firms, they choose to do business with. Consumers in this day and age have come to anticipate that things will be completed within a reasonable amount of time and also want to have a positive experience with the companies they choose to do business with.

As illustrated on chapter four, we were able to clarify solution in terms of cost saving and effectiveness by implementing freePBX which is a Linux based web-application for monitoring call traffic. The existing implementation price is around 100.000 USD for 50 users. And solution cost 5000 USD between 50 and 100 users which saves 90% as discount. In terms of effectiveness, the system has web based interface that helps call center admin to perform their operations without using scripting commands.

It is recommended that future researchers could integrate the implemented call center with other Web Apps.

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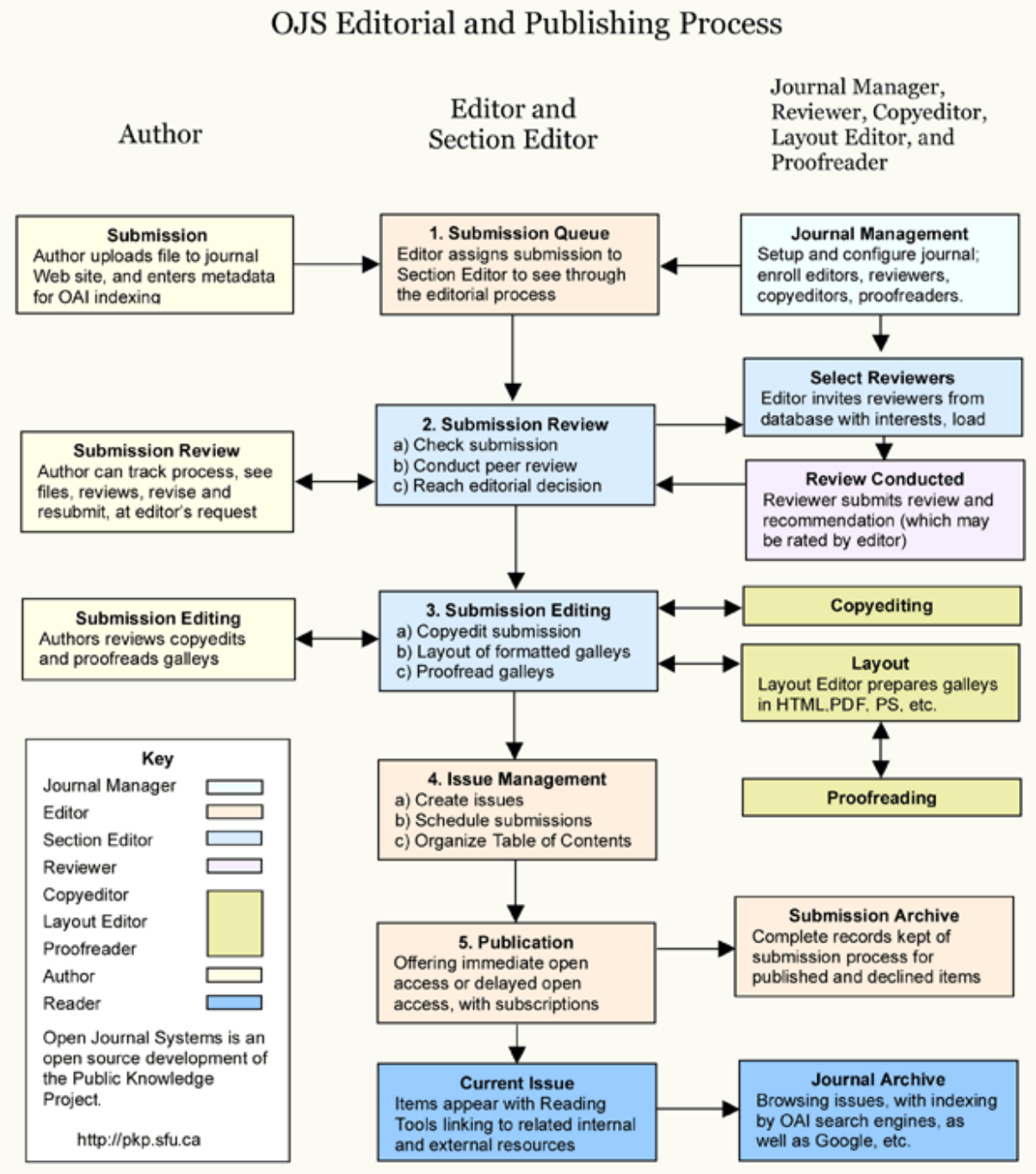

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