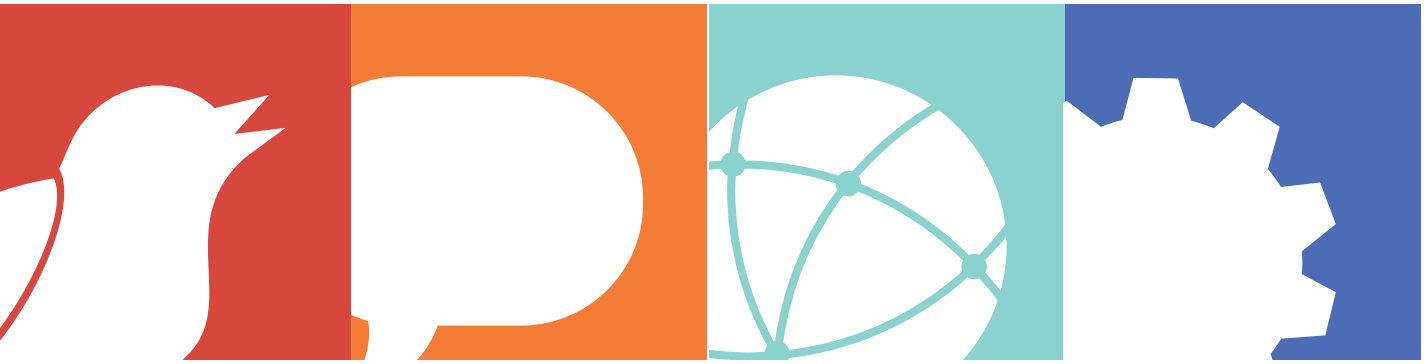
MARCH 2024 AUSTRALIA BRASIL INDONESIA MALAYSIA

WREN Symposium 2024

COLLABORATING TOWARDS THE SUSTAINABLE DEVELOPMENT GOALS

BOOK OF ABSTRACTS



Publisher:
University of Wollongong
Northfields Ave, Wollongong NSW 2522

PREFACE

Welcome to the conference proceedings of the Women's Research Engineering Network (WREN) Symposium 2024 – "Collaborating towards the Sustainable Development Goals."

The journey towards sustainable development is one that requires collective effort, innovative solutions, and interdisciplinary collaboration. It is a journey that transcends borders, disciplines, and sectors, requiring us to come together to address the complex challenges facing our planet and its inhabitants.

In these proceedings, you will find a diverse collection of research papers, each offering valuable insights and innovative solutions aimed at advancing the Sustainable Development Goals (SDGs). From ending poverty and promoting health and wellbeing to ensuring inclusive education and fostering economic growth, the research presented here exemplifies the dedication and commitment of researchers towards building a more sustainable and equitable world.

As we navigate the challenges and opportunities on the path towards achieving the SDGs, it is essential to recognize the critical role that research plays in informing policy, inspiring action, and driving positive change. The contributions in these proceedings reflect the tireless efforts of researchers from around the world who are dedicated to making a difference in their communities and beyond.

We extend our sincere gratitude to all the authors, reviewers, and contributors who have made this publication possible. Their dedication, expertise, and passion for sustainability have enriched our collective understanding of the complex issues facing our world today.

As we embark on this journey together, let us continue to collaborate, innovate, and advocate for positive change. Together, we can make meaningful strides towards a more sustainable, inclusive, and prosperous future for all.

Thank you for joining us on this journey.

WREN Committee

2024

ABOUT THE WOMEN'S RESEARCH ENGINEERING NETWORK (WREN)

At WREN, we are committed to achieving gender equity in engineering fields, striving to increase participation and retention among all genders, with a special focus on women. Our vision is a world where engineering is equally accessible and rewarding for everyone, and our purpose is rooted in creating a sustainable and equitable environment that values diversity and inclusivity. This commitment is reflected in our mission to serve as a dynamic platform for international collaboration among women research engineers, enhancing their visibility and encouraging supportive policies. We connect women across various stages of their careers — early, mid, and senior — through international collaborations, including grant proposals, joint publications, and co-teaching partnerships. Additionally, we maintain and deepen relationships with international partners, equip our members with career-advancing tools, amplify research led by women and underrepresented groups, and tackle systemic barriers through grassroots advocacy. Through these efforts, WREN not only supports individual career growth but also contributes to reshaping the engineering landscape into a more inclusive and equitable field. To learn more about our work or to join our network, please visit our website (https://thewren.global/) and get in touch.

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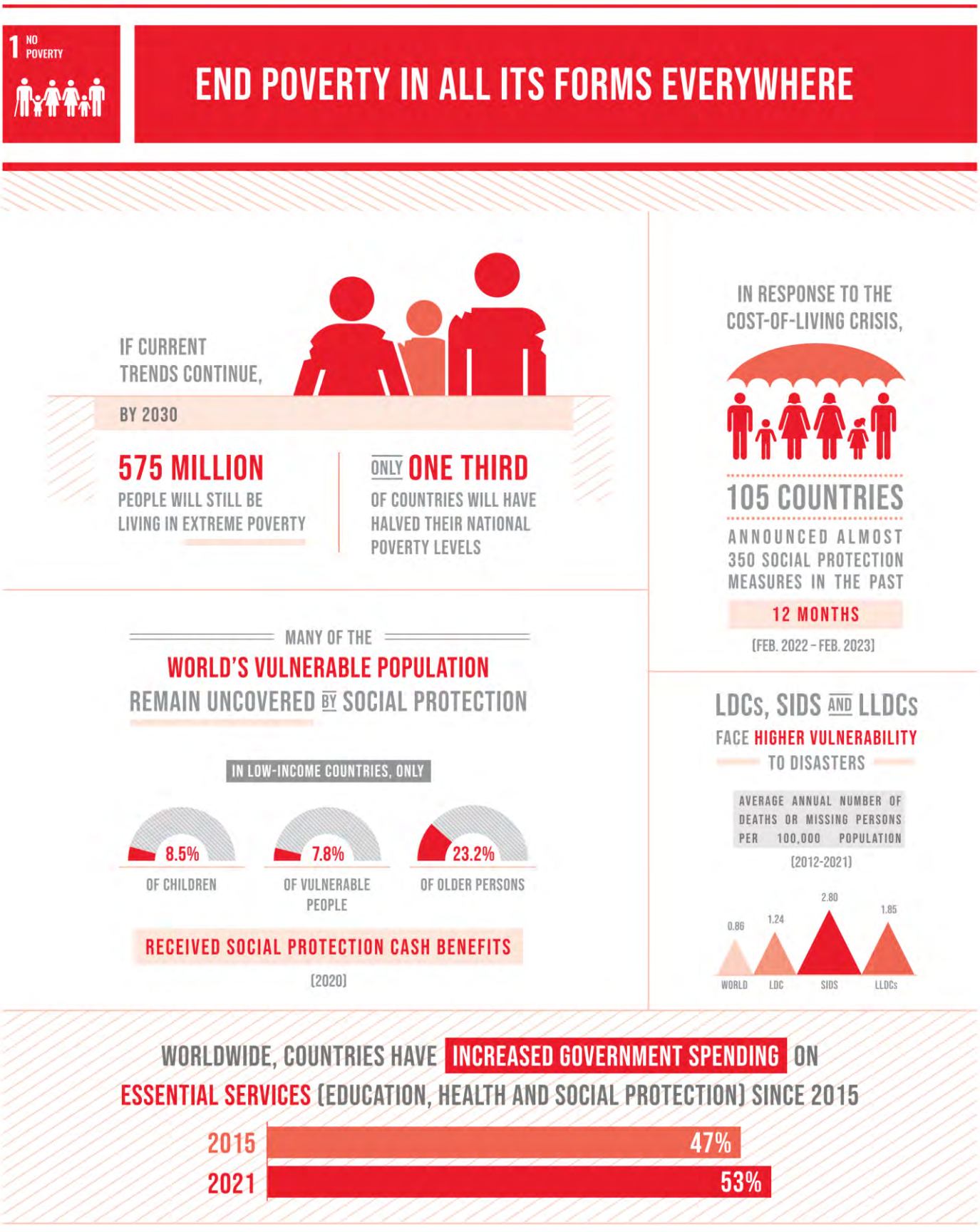

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REVIEWING MICROHOMES THROUGH SDGS AS AN ADDITIONAL SOLUTION TO AUSTRALIA'S HOUSING CRISIS

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ABSTRACT

The United Nations (UN) Sustainable Development Goals (SDGs) were used in this paper as a framework for evaluating microhomes as an alternative strategy in finding a solution to Australia's housing crisis. Through reviewing existing literature and forming a baseline of the current Australian housing crisis, microhome were assessed against SDGs and compared against high density development. While high density planning offers greater convenience and efficiencies of infrastructure for city centres and transport hubs, the conventional developer-led construction model with central focus on maximising profit will tend to come up against many SDG targets. In contrast, microhomes offer a uniquely diverse package of opportunities for resident-centred housing development and management with innovative pathways into ownership and connections with communities and the natural environment.

Keywords: Microhome 1; Sustainability 2; SDG 3; Housing Crisis 4; Development Program 5.

INTRODUCTION

Australia is currently facing a housing affordability crisis spurred by over-financialization of real estate, negative gearing, and immigration [1], [2]. The number of households has increased dramatically by 20% in 10 years from 7.76 million in 2011 to 9.275 million in 2021, while household size has fallen to an average of 2.5 with more than 25% of Australian households now comprising of one person [3]. November 2023 saw an average 4.7% turnover of housing stock in Australia [4]. This lag leaves a substantial mismatch between the present housing stock and present household sizes. Australians are also experiencing rental and mortgage hardship due to an increase to the cost of living and a stagnation of income [5].

The NSW Government Transport Oriented Development Program looks to deliver much needed housing around 39 transport hubs through enabling increased housing density [6]. The NSW Productivity Commission has identified benefits of increasing housing density to curb the urban sprawl, including higher amenity and greater productivity [7]. This study proposes microhomes as a complementary solution to the development program, one with an alternative mix of affordability, enhanced connections to land and community, and lighter environmental footprints within a sustainable and compact living space. Envisioning alternative paths forward for disadvantaged communities increases the scope of individuals that can access higher standards of living. This paper uses the framework of the UN SDGS to assess the sustainability of the microhome solution.

ASSESSMENT OF MICROHOMES WITHIN THE SDG FRAMEWORK

SDGs target more sustainable and equitable development throughout the world. In this review the ability of microhomes to sustainably address the Australian housing crisis is scrutinised under seven notable SDG targets. Furthermore, the authors of this paper bring forward their own experience through their participation in the Builder Architecture Design Competition - Microhomes, which navigates the design an off-grid modular microhome to address sustainable economies and socio-cultural challenges.

SDG targets 1.3 and 1.4 focus on implementing social protection systems particularly for the poor and vulnerable, including equal access to basic services, modern technology, and ownership of real estate [8].

Housing provides a safety net for vulnerable individuals and reduces their risk of ongoing poverty and reliance on government support [9]. Transportable microhomes offer a low-cost entry point into home ownership and offer the potential to decouple this from pre-requisite land ownership, unlocking more affordable housing options. However, land tenure remains uncertain under evolving regulations [10]. Establishment of secure affordable land tenure for communities of transportable microhomes is an empowering step towards this target. In contrast, using microhomes as granny flats or temporary accommodation retains control and power with the landlords who manage them. An example of a successful microhome inclusive land trust is the Narara Eco Village, north of Sydney, that focuses on community engagement and sustainability for residents that also want to retain ownership of their own home and land [11]. This shows potential paths forward as a densification alternative to granny flats and high rise, with options for greater equity of ownership and control granted to microhome occupants. Furthermore, microhomes offer a unique compact housing package that can incorporate basic energy services and thermal comfort at a very low operating cost [12]. This combination of low purchase cost and low operating cost make microhomes well aligned with targets 1.3 and 1.4.

SDG 3.5 aims to improve the prevention and treatment of substance abuse while target 3.4 looks to promote mental health and wellbeing [8]. According to the 2021 Census in Australia, 122,000 people experience some form of housing instability, either living in improvised dwellings, homeless specific accommodation, temporary accommodation, boarding houses, or in overcrowded conditions [13]. Within this group a longitudinal survey found that 57% partook in risky alcohol use, 39% percent used illicit drugs, and 14% were injecting drugs [13]. Homeless services in Melbourne showed research that two thirds of the homeless demographic developed substance abuse issues after homelessness, with the issue becoming prolonged due to being stuck within a community that perpetuates the lifestyle [13]. Comparing the outcomes of housing first versus treatment first for homeless persons, it was shown that providing unprohibited housing that doesn't rely on abstinence only behaviour correlates strongly with a greater likelihood to discontinue substance abuse and a decreased likelihood to drop out of treatment services [14], [15]. An alternative to mixing users and non-users in their own micro-community, is providing microhomes in unused plots within already established neighbourhoods to allow for the inhabitant to become part of a community that promotes wellbeing.

SDG targets 8.3 and 8.4 look towards supporting economic growth with development-oriented policy, improving resource efficiency in consumption, and creating productive employment and decent work all without degrading the environment [8]. Australia has seen stable economic growth over the past few decades, with an annual average GPD growth of 3.3% from 1992-2017 [16]. However, the housing crisis has cast a dark, divisive shadow over this economic prosperity, where the reformulation of housing policy as a financial asset rather than a human right has fed this economic growth, leaving Australia in a situation where housing is inaccessible for an increasing proportion of the population [1], [2]. This is reinforced with the median price for housing in Australia growing from three times the median income in 1990 to eight times the median income in 2021 [17]. Many affordable microhomes have the potential to bypass mortgage requirements due to their low cost, allowing for occupants to focus on pursuing fulfilling careers instead of working to pay off debt. Restructuring Australia's housing policies to cater towards equitable accessibility over financial gain makes housing security a realistic outcome for marginalised people, while also working to increase sales of infrastructure. Microhomes also create an avenue of employment opportunities as development of these microhomes expands on a currently undermined market that benefits private contractors and local businesses that focus on manufacture, design, and technology [18].

SDG targets 11.1 and 11.3 endeavour to make safe, resilient, and affordable housing accessible to all through inclusive and sustainable urbanisation of settlements [8]. The Australian 'City Deals' program similarly focuses on these values by using a government strategy that focuses on transforming infrastructure, land-use planning

and urban city planning that improves social outcomes and housing [19], [20]. A microhome's compact size means that they can easily be oriented for favourable solar passive access and have surrounding garden space for both safe comfortable privacy and a connection to community [21]. Their low-rise height and compact footprint reduce the potential to cast shadows on adjacent neighbours, and being standalone dwellings even within communities, they are a compact, flexible, and adaptable solution to the current densification of urbanised Australia. They are also equally well-suited to provide sustainable medium-term disaster response housing in line with target 11.5 which focuses on reducing life and economic loss associated with natural disasters [8]. High-density high-rise development in cities have an advantage in taking up less floor area and allow more room to incorporate, safe and green public spaces [22]. Microhomes in contrast are better suited to low-to-medium density with access to green spaces naturally around each home, making both residential options viable when considering target 11.7 [8].

SDG 12 targets sustainable consumption and production [8]. The compact size of microhomes aligns closely with the goal of appropriate production and consumption, minimising wasted space and materials, especially considering the decrease of Australian household size [3]. High-rise apartments are reported as requiring significantly higher embedded carbon during construction compared to detached dwellings, while the much smaller footprint of microhomes will tend to require proportionately lower embedded carbon again compared to conventional detached dwellings [23]. Finally, manufactured microhomes are well-suited for embedded sustainable self-sufficient design for clean water and affordable clean energy targets of SDG 6 and 7 [12], [8].

CONCLUSIONS

Microhomes have been assessed through the SDG framework in their suitability as a sustainable solution to address Australia's housing cris. Throughout this review microhomes were found to be a suitable alternative to proposed high density development schemes. Microhomes were seen to address several SDGs; reducing poverty, improving mental health and wellbeing, integrating clean energy and water, promoting decent work and economic growth, creating sustainable cities and communities, and embedding responsible production and consumption [8].

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GOAL 3: ENSURE HEALTHY LIVES AND PROMOTEWELLBEING FOR ALL AT ALL AGES

Source: UN's The Sustainable Development Goals Report 2023 – Special Edition

SUSTAINABLE FOOD LANDSCAPE: A SPATIAL STUDY IN LOCAL COMMUNITY AT KALISUSUH

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ABSTRACT

Food landscape has a strong spatial context—every food landscape in a particular geographical context is unique and may differ from the other. This study explored an inclusive concept about community food landscape and its relationship with spatiality by exposing several spaces that need to be created and protected to achieve sustainable food landscape. Those spaces were social spaces and ecological spaces, which may not only be perceived as something physical. Kalisusuh Village was an interesting community located by the Cacaban Reservoir, showed a continuous dialogue between the community and their environment. A phenomenological approach was chosen to find out what is generally experienced by the community. The field surveys were conducted in two different seasons of the village, which were dry and rainy seasons. Open-ended interviews were also conducted with some food actors involved in the community to get a complete depiction of the food landscape. In this community, the strongest spatial context were ecological spaces, economic spaces, and cultural spaces—where social, political, and intellectual spaces were underdeveloped. Every space mentioned was intertwined and interdependent to maintain the sustainability of the food landscape. This understanding could be a potent starting point to formulate further sustainable development strategies.

Keywords: community; food landscape; rural; sustainability; spatial context.

INTRODUCTION

Improving food production and consumption systems is at the core of any discourse on sustainable development from both an environmental and socio-economic perspective [1]. Even more than that, to achieve a sustainable food landscape, a long-term, multidimensional and fundamental transformation process is necessary. This transition must be specific according to the cultural context and policies [2]–[4], and also should be applied gradually, from community scale to global scale.

Literature and research on food landscape has started to develop since the early 2000s. However, these studies were still limited in Indonesia. However, this research was a sequel to a previous literature review about sustainable food landscape that has been presented and published on a book chapter of “Urban Development and Lifestyle” [5]. That chapter discussed about the 3 levels of understanding food landscape [5], [6] including food system, food spaces (social and ecological spaces), and supporting factors. Those are interwoven in a complex network, resulting uniqueness and authenticity in each region. Therefore, understanding spatial context and doing respatialization is crucial in developing sustainable food landscape.

This study seeks the universal essence of the spatial context in community food landscape of Dusun Kalisusuh towards sustainability. This study also captured series of interactions of the physical and non-physical spaces formed in the village’s food landscape, learning how these spaces can survive and play potent roles in sustainable food landscape.

MATERIALS AND METHODS

Phenomenological approach was chosen in this study, where the main objective is to obtain the universal essence of a phenomenon in a community or population (what is experienced in general by a community) [7, p. 58]. As descriptive-narrative research, this study described the phenomena that existed sequentially and revealed the relationship and function of each element in the food landscape as a structural unit that together produces a comprehensive system. The research was conducted in two stages, started in October 2019 to July 2020 (10 months). The first stage was literature review about sustainable food landscape, where previous studies and theories were summarized and mapped into a complete concept. This concept was then adapted as units of analysis to observe the food landscape phenomenon that occurs in Kalisusuh community. The result of the study explained the role of ecological and social spaces in food landscape in Kalisusuh community towards sustainability.

Primary data collection was carried out by observation and interviews. Researcher lived in the community for a week in 2 months, so that the daily life of the community from various seasons (high tide during rainy season and low tide during dry season) could be well documented. Observation was performed by taking notes and photos at each visit about various spaces (ecological and social spaces) in the food landscape.

Interviews were conducted with 8 food actors with purposive sampling method in the community. Respondents were local residents with various livelihoods that are directly in contact with the food landscape (fishermen, farmers, fishermen and farmers, food stall traders, housewives). To find out more about the socio-political structure of the community and the history of the community, interview with the seniors were also conducted. The results of the interviews were transcribed and coded. The codes were classified and presented in a table. The software used in this process is Microsoft Word and Microsoft Excel with script modification using Spyder 4.1.1 to extract the codes from the transcription. This extraction was automatically delivered into .xlsx format, then processed by coding modification using Microsoft VBA to sort the generated codes structurally and systematically. Secondary data were information collected from websites, magazines, newspapers, to complement and validate the interviews.

RESULTS

ECOLOGICAL SPACES

The quality of ecological space generates spatial pattern, productivity, and interdependent interaction between a community and its natural feature to maintain a sustainable ecosystem through social spaces (including cultural and economic spaces). Cacaban Reservoir has become an important part of the daily life of the Kalisusuh community. This reservoir is not only seen as a natural feature adjacent to their residence, but also plays a big role as source of their livelihood. In fact, the surrounding community has a big responsibility in preserving the reservoir, because the Cacaban Reservoir is vital for Tegal's agriculture in general.

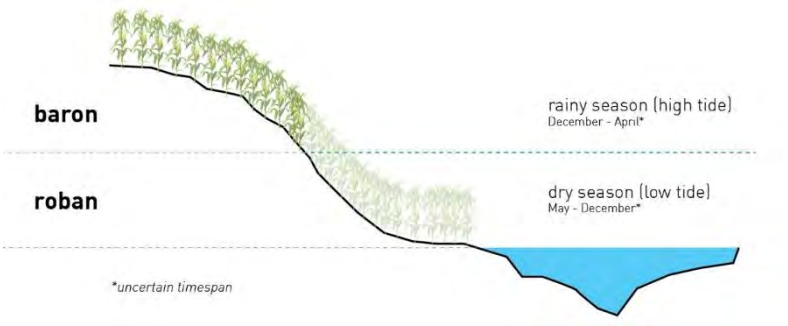

Figure 1 Section of uphill—intertidal zonation in Cacaban Reservoir.

The geographical conditions of Kalisusuh community forces the local people to be responsive to seasons. The intertidal zone becomes important to the community as it is used as food production space. That zone is called "*roban*" by the locals and is called "*lahan pengairan*" (irrigation land) legally as it belongs to the Tegal's Irrigation Agency. When the reservoir starts to recede at dry season, residents will quickly plant the land with corn to increase their income. This movement of production space from *baron* (or uphill, see Figure 1) to the *roban* (intertidal zone) also is an effort to plant as close as possible to water sources since they depend only on rainfed irrigation system.

Apart from irrigation for agriculture, Cacaban Reservoir is also a source of livelihood through its aquatic biota, namely freshwater fish. Since 2018, the government has begun to pay attention to the sustainability of freshwater biota and the welfare of the surrounding community (especially fishermen). They began to provide fish nursery assistance, counselling, and also enforcing fishing regulations for fishermen.

Cacaban Reservoir is also act as transportation infrastructure to support the food system. The land routes are generally narrow, hilly, and slippery when it rains, thus, farmers and transport laborers prefer to use waterways (the reservoir) to transport their crops. This water transportation is considered to be much more effective than land routes.

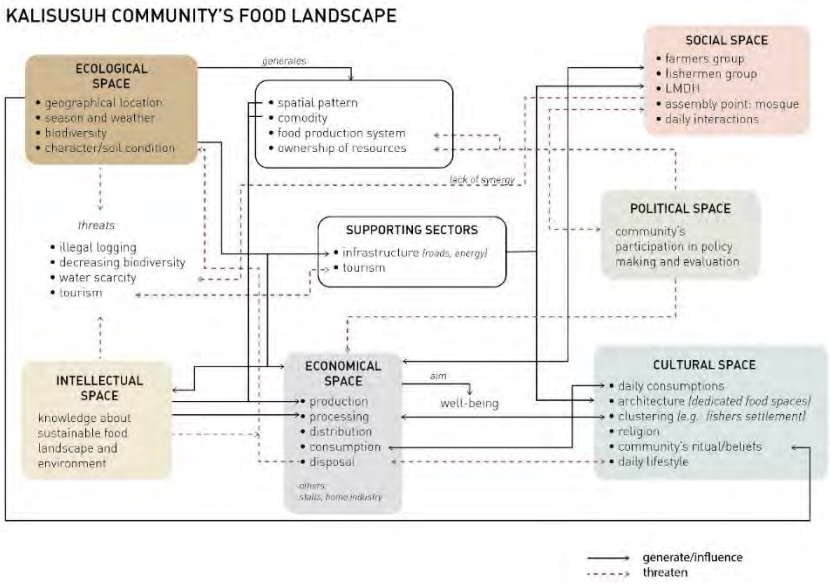

Figure 2 Kalisusuh community's food landscape summary diagram in spatial context.

SOCIAL SPACES

Practically, each stage of the food system (production, distribution, processing, consumption, and disposal) takes up space. These spaces exist as a form of interaction that occurs in communities, responding to the presence of ecological spaces. Social spaces in food landscape exists in physical and non-physical forms, with the community as the actor, and the development is driven by many supporting sectors, especially transportation and infrastructure. The scope of social spaces including economical, social, cultural, intellectual, and political spaces that are interdependent to each other.

SUPPORTING SECTORS

The community's economy had improved since the infrastructure improvements. Until before 2006, the road conditions were very bad—only paths that was often covered with grass, no vehicle access. With the construction of roads, all access to healthcare, education, and other necessities of daily life became easier, allowing the access of various modes of transportations, such as trucks and cars to facilitate distributions.

The total length of the road in Kalisusuh community is approximately 6 km. Road infrastructure is the pulse of the Kalisusuh community's food landscape.

SUSTAINABLE FOOD LANDSCAPE STARTED FROM THE SMALLEST SOCIAL UNIT

To achieve a sustainable community food landscape, there are some steps needed to be taken not only at the community scale, but primarily from the smallest unit scale: family. In this community, the concept of sustainability that they understood was simple: they wanted what they have now could be enjoyed by their children and grandchildren in the future.

CONCLUSIONS

After tracing the role and quality of food spaces (ecological and social) in supporting the sustainability of the food landscape, this study also conducted on the behavioural patterns of its users.

All findings about the food landscape in Kalisusuh only covered the elements of the food landscape horizontally. Thus, a more specific and deep discussion on each space, both from ecological space and social space, can be carried out in further research. As an example, the soil conditions as the quality of ecological space. If permaculture is one of the right systems to maintain diversity and food security—by considering all aspects of the principle of sustainability—can this be applied in this community and be sustainable?

Likewise, due to limited time and energy, a study of the typology of physical space in food landscape, namely production, processing, distribution, consumption, and disposal space should be discussed in more detail. For instance, examining the relationship between food space organizations and daily living spaces in people's homes in the community (with a larger sample), or examining how individual or collective disposal spaces look like. Research on food landscapes in a spatial context ultimately encourages multidisciplinary collaboration to sustain the food landscape.

ACKNOWLEDGEDMENTS

This paper and the research behind it would not have been possible without supports from: Mr. Bachtiar Djanan and Mr. Tri Wihardjo, as they introduced the beauty of Kalisusuh community to us for the first time; Mr. Sakrip & Mrs. Tini who accommodated us during our stay in Kalisusuh with such hospitality; the interviewees, people in Karanganyar and Penujah for accepting us and letting us learn from them; and our beloved families and friends.

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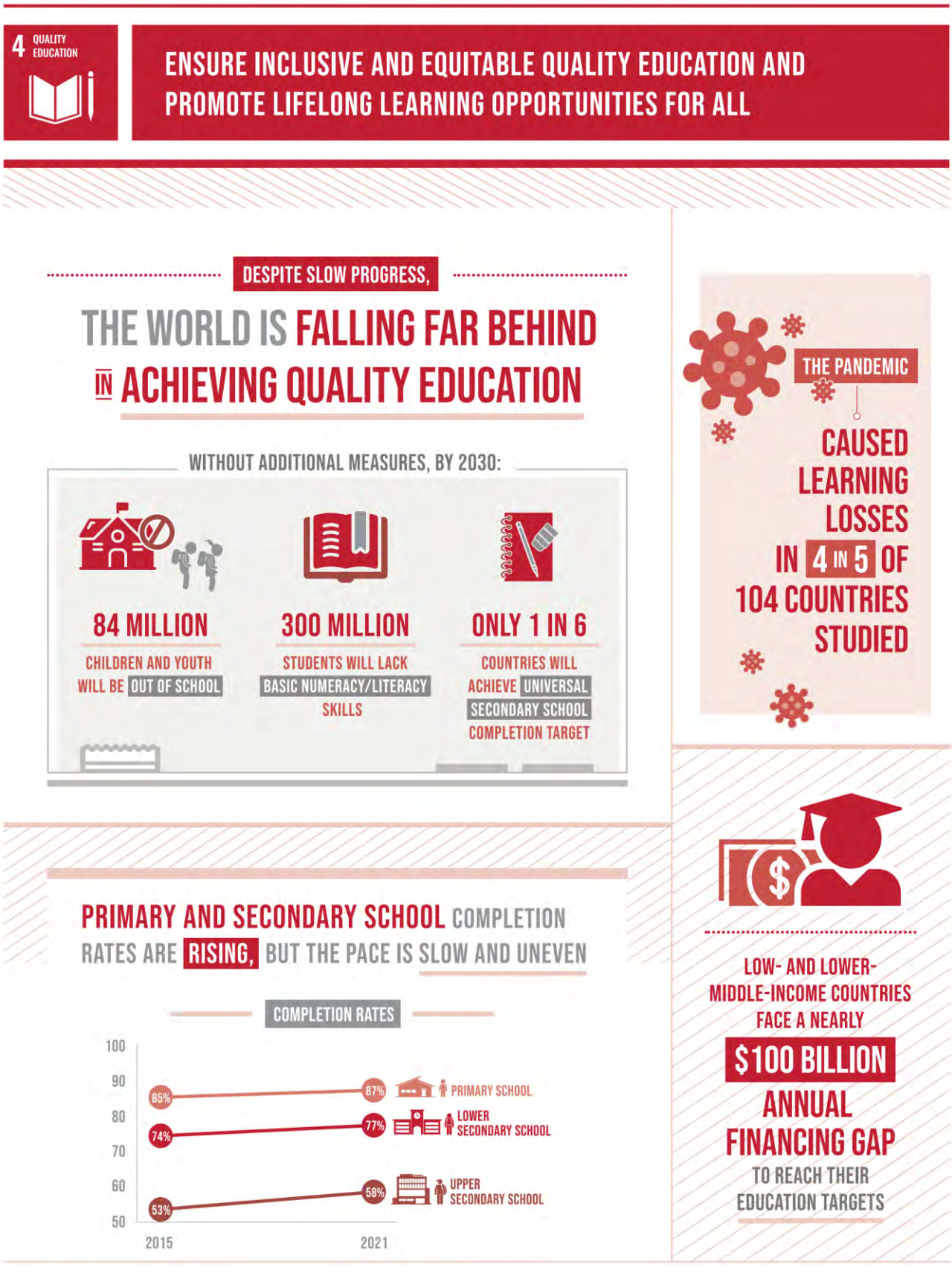
GOAL 4: ENSURE INCLUSIVE AND EQUITABLE EDUCATION AND PROMOTE LIFELONG LEARNING OPPORTUNITIES FOR ALL



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THE IMPACT OF AI ON ASEAN TERTIARY STUDENTS' CAREER READINESS IN INDUSTRY 4.0

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ABSTRACT

The study explores the increasingly significant role of Artificial Intelligence (AI) within Higher Education (HE) across ASEAN countries, highlighting its potential to enhance students' career readiness amid the advancements of Industry 4.0. As the Fourth Industrial Revolution (4IR) unfolds, there is an urgent need to reconsider the skills required for success within the ASEAN labor market. This paper conducts a systematic review to provide a comprehensive analysis of AI's impact on enhancing career readiness among tertiary students in the ASEAN region. The study examines both the opportunities and challenges presented by the integration of AI for student learning in ASEAN HE systems. The finding demonstrates that AI has the potential to significantly enhance critical future skills, such as analytical and creative thinking, along with self-efficacy, which are crucial in the 4IR job market. Nonetheless, the efficacy of AI in education varies on the quality of AI systems, and the data they are trained on and is subject to challenges including digital divides, algorithmic biases, ethical issues, and the risk of excessive dependence on technology. The paper argues for a reimagined educational approach that enhances the synergy among ASEAN countries' governments, academic institutions, and the industry sector to better prepare students for future employment.
Keywords: Artificial Intelligence (AI), Higher Education (HE), career readiness, student's global skills, ASEAN labor market.

INTRODUCTION

AI is today one of the most widely hyped technologies [1]. Concepts of AI multiplied and expanded, often ending up involved with the philosophical concerns of what constitutes 'intelligence' and whether machines might ever truly be 'intelligent' [2]. For this study, AI may be pragmatically defined as computer systems that are designed to interact with the outside world using capabilities that are typically associated with humans [3]. According to UNESCO [2], there are four techniques of AI: Classical AI, Machine Learning, Neural Networks, and Deep Learning. This work will only focus on AI that uses the deep learning technique which involves multiple layers of neurons used for learning complex data representations and has been highly effective in handling unstructured data, such as in image and speech recognition tasks [2]. Some examples of AI that uses deep learning techniques are Adaptive Learning Systems, Intelligent Tutoring Systems (ITSs), AR/VR, Chatbots, Learning Analytics, Speech/Face Recognition, and Content Generation. This study will investigate the potential opportunities and risks associated with employing AI for the development of Industry 4.0-aligned global skills among ASEAN students, and then propose some recommendations for ASEAN countries.

LITERATURE REVIEW

AI ADOPTION IN HIGHER EDUCATION (HE) IN ASEAN COUNTRIES

In the field of education, AI has globally come a long way since its infancy, playing an increasingly important role in areas such as student-oriented AI (learning and assessment software), teacher-oriented AI (teaching aids), and system-oriented AI (administrative solutions) [4]. The adoption of AI in HE by students, teachers, education institutions in ASEAN countries is an evolving process that is influenced by social, economic, and infrastructural considerations [4]. Countries like Singapore have been frontrunners in leveraging AI for diverse educational purposes such as administrative functions, customized learning, and predictive analytics for improving student outcomes [4]. Conversely, in countries with lower levels of digital literacy and infrastructure, the AI adoption

narrative is marked by efforts to bridge the digital divide and improve basic access to technology for students and educators [5].

With system-oriented AI, educational management information systems are increasingly utilising AI to automate administrative activities such as admissions, scheduling, and assignment monitoring [6]. They are frequently applying learning analytics to analyse big data from learning management systems [7]. This leads to visual 'dashboards' [8] which enable data-driven decision-making and policy development and develop personalised instructional content [9]. Several ASEAN member states have established learning analytics systems to facilitate administration in higher education [10]. Despite the benefits, the use of AI rises ethical and quality issues, requiring accurate, unbiased data and powerful computational strategies, and provoking ethical discussions about student data privacy [11], [12].

With student-oriented AI, AI adoption was created to provide personalised, high-quality, and pervasive perpetual learning to learners worldwide, regardless of their educational setting (formal, informal, or non-formal) [2]. AI has the potential to facilitate innovative assessment methods, such as continuous and adaptive evaluation [13]. Intelligent tutoring systems, exploratory learning environments, automated writing evaluation, AI-supported reading and language learning, virtual and augmented reality, and AI-enabled collaborative learning are promising applications of AI for learning and assessment [2]. All of these AI deep-learning technologies have been increasingly adopted in ASEAN countries including Singapore, Indonesia, Thailand, Philippines, Vietnam and so on [4], [14], [15], [16]. Nevertheless, it is essential to recognise that the application of AI in learning and assessment raises several remaining problems including a pedagogical approach, lack of persuasive proof for their efficacy, possible impacts on teacher roles, and broader ethical concerns [12].

With teacher-oriented AI, the increasing presence of AI in classrooms will inevitably reshape teacher roles, thereby demanding the development of new competencies to effectively utilize AI and a focus on professional development to enhance human and social skills [2]. Despite concerns that excessive automation could undermine the social role of teachers, emerging focus is on developing tools to support teachers, ex AI-driven forum monitoring and AI-powered teaching assistants [17]. However, several technical, pedagogical& ethical issues must be addressed before they can be effective in real environments [3], [18].

ENHANCING STUDENTS' CAREER READINESS IN INDUSTRY 4.0 THROUGH AI-DRIVEN PROMOTION OF GLOBAL SKILLS

The Industry 4.0 creates the application of the most recent advances in automation and data sharing in manufacturing technologies, such as cyber-physical networks, Internet of Things, Cloud, and AI, to develop an extensively connected production model of customised products and services, thereby refining conventional industries into smart industries [19]. With automation, data exchanges, cloud computing, cyber-physical systems, robots, big data, AI, the Internet of Things, and semi-autonomous industrial techniques, ASEAN nations are experiencing unprecedented industrial transformation [20]. The World Economic Forum predicts that automation and AI will have a significant impact on the Industry 4.0 by eliminating many occupations and radically reshaping others [21]. It is estimated by [14] that by 2028, to generate the same degree of productivity as today, these economies in ASEAN will require 28 million fewer employees, or more than 10 percent of the current ASEAN-6 workforce (Figure 3).

The Predicting Global Skills Trend in 2023-2027 which is built on the Global Skill Taxonomy defines the Industry 4.0 critical skills includes: 1) Attitudes (Self-efficacy; Working with others; Ethics) and 2) Skills, knowledge and abilities (Cognitive skills; Management skills; Engagement skills; Technology skills; Physical abilities) (World Economic Forum, 2021) (World Economic Forum, 2023). Among these skills, some most critical skills on demand for the future job market in ASEAN which will be discussed this study will be 1) Cognitive skills include Analytical thinking and Creative thinking skill and 2) Self-efficacy skill (World Economic Forum, 2023; World Economic Forum, 2021). These skills are now regarded as crucial for future career readiness [21]. Undoubtedly, ASEAN nations need to act more speedily to equip young people, especially university students, with the critical and vital skills necessary for career success in the era of Industry 4.0.

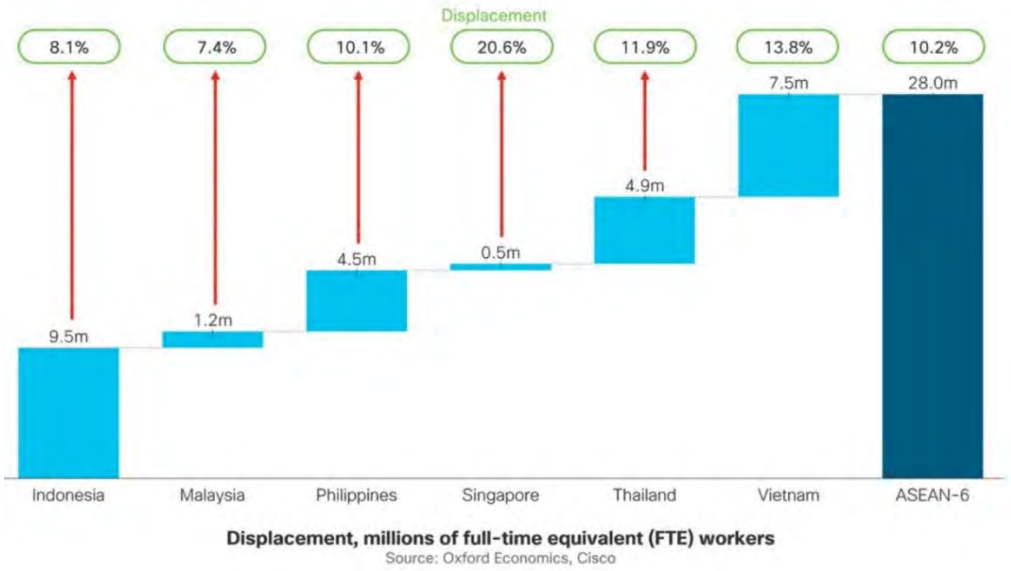

Figure 3. Jobs that will be displaced under new technology scenario by country [14].

From this background, the research question of this study will be: How AI adoption affects to ASEAN HE Students' Global Skills and Career Readiness in Industry 4.0: What are the Opportunities, Risks, and Implications for HE?

METHODS

This Systematic Literature Review (SLR) follows an enhanced methodology adapted from Kitchenham's guidelines [22] incorporating best practices for conducting comprehensive and systematic reviews. The SLR process is structured into three main stages: Planning, Conducting, and Reporting, each with specific tasks and criteria designed to ensure a thorough and unbiased review of literature on the impact of AI adoption in ASEAN HE students' learning and its impact on career readiness. A comprehensive search strategy has been developed, incorporating relevant keywords ('AI', 'higher education', 'career readiness', 'ASEAN students' 'student's global skills') and Boolean operators to refine the search from databases including ProQuest, SAGE Journals Online, Google Scholar with peer-reviewed articles from 2010 onwards, ensuring the information was both current and relevant. To ensure a focused and relevant literature review, the search strategy targeted specific keywords and databases, with an emphasis on peer-reviewed articles and authoritative reports. The initial selection of 253 articles was refined to 54, based on relevance and quality criteria. These 54 papers have been through an assessment of the quality of included studies, considering factors including study objectives, methodologies, findings, and implications. Data from selected studies has been extracted and synthesized to address the research question. This targeted approach aims to provide a comprehensive overview of AI adoption's impact on developing student skills and career readiness in the ASEAN context, particularly focusing on six leading economies: Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam [14]. By following this revised methodology, the SLR will contribute valuable insights into the role of AI in developing student's career readiness in the ASEAN region.

RESULTS

AI AND ANALYTICAL THINKING SKILL

AI adoption in HE in ASEAN has the potential to considerably enhance student's analytical thinking skill. Analytical thinking skill is the ability to break down complicated ideas and notions to core or basic principles [24]. Intelligent Tutoring Systems (ITSs) - such as SQL-Tutor, ALEKS, and ASSISTments - are AI-based platforms that serve as practical illustrations of AI potential improvement. These systems cultivate argumentative skills and provide personalised feedback to stimulate analytical thinking [25]. Singapore is

quickly moving ahead with the use of learning analytics and big data from learning management systems and ITSs to improve personalised learning [10]. ITSs have also been utilised extensively in Indonesia to identify each student's abilities level so that learning can be individualized [26], [27]. Through the use of this AI tool, students participate in a symbiotic learning environment that simulates human-like processes of critical evaluation, in which they learn both from and with AI [28]. This viewpoint is consistent with post-humanism theory, which advocates extending and enhancing human capabilities by reimagining the human body and mind as part of a larger network that interacts with the environment and technology [29]. Consequently, AI platforms such as ITS can be regarded as cognitive extensions consistent with this post-humanism viewpoint [30].

However, it is essential to recognise the limitations of AI such as ITSs. Specifically, the technical challenge is designing this AI tool capable of accurately interpreting and responding to a broad range of student inputs, particularly for open-ended analytical tasks [31]. This limitation may compromise the effectiveness of AI like ITSs in cultivating comprehensive analytic skills, especially in complex subjects requiring higher-order thought. In addition, while some AI as ITSs has demonstrated promising results comparable to traditional classroom instruction [7], and despite their widespread adoption in many educational systems in the ASEAN region, there is limited evidence for the efficacy of commercially available ITSs [15], [26], [32], [33]. Moreover, there are numerous challenges and risks linked to the broad implementation of AI technologies like ITSs which revolve around data ownership (for instance, the misuse of data for monetary benefit), consent (such as the question of whether students are equipped, either from an educational or legal standpoint, to give genuine consent), and privacy (like the handling of student information), all of which result in evolving ethical and legal dilemmas related to educational data and algorithms [2]. No guidelines, policies, or regulations have been adopted in ASEAN to resolve the specific ethical concerns raised by the use of AI in HE [32]. The question of how AI tools can be optimised properly for effective student and classroom use remains an important area for future research [2], particularly when the goal is to develop students' analytical thinking abilities.

AI AND CREATIVE THINKING SKILL

Adopting AI techniques such as Virtual Reality (VR) holds substantial potential in fostering creative thinking among HE students in ASEAN countries. Creative thinking is the ability to conceive something that does not exist and put a new idea or concept into life through imagination [24]. It has been argued that AI deep learning technologies such as VR improve specific factors that increase student creativity, and a natural environment can be regarded as a factor that increases creativity [33]. Considerable effort has been devoted to integrating virtual reality (VR) into education to foster professional abilities and enhance creativity [34]. Immersion enhances co-correlation in creativity-relevant capacities such as empathy and imagination, according to [35], who conducted a study based on the use of avatars in virtual worlds such as Second Life Similarly. A separate investigation found that training in a virtual setting not only enhances creativity-related procedures including personality traits and cognitive styles but also promotes creativity [36]. In Thailand, for example, Chulalongkorn University has implemented AI in various design and art courses to encourage creative problem-solving [16]. In Vietnam, universities have started integrating AI-based simulators into their curriculum to teach students about environmental systems and sustainability [15].

The application of VR in education can stimulate students' creativity, based on the theory of constructivism, in which students actively construct or interpret their own reality based on immersive VR experiences [37]. Empirical evidence suggests that virtual reality, by embodying constructivism's principles, promotes experiential learning in a contextually relevant environment [38], thereby fostering creative thought. Using VR tools designed with an experiential learning approach, for instance, enables students to navigate through a four-stage learning cycle - concrete experience, reflective observation, abstract conceptualization, and active experimentation - which facilitates creative exploration of knowledge and problem-solving [39].

Nevertheless, there are several limitations and potential issues with AI adoption such as VR usage in educational settings. There are various challenges that stakeholders face in using VR technology in educational activities, such as course design investment, financial consideration, health concerns and technology management [40]. When using headphones, VR technology can cause pain, most notably motion sickness and headaches [41]. Consequently, it is crucial that the appropriate technology is chosen for the

learning cases. Inadequate use of technology, such as limiting the number of headsets per classroom due to cost and visual latency due to poor internet connectivity, can exacerbate negative educational outcomes [42]. Given that the adoption maturity of AI in HE in ASEAN countries is varied and influenced by social, economic, and infrastructural factors, it has the potential to exacerbate existing education disparities in the region [2]. Furthermore, lecturers confront trade-offs between the potential benefits of VR and the significant course design investment necessary to integrate VR into a course, particularly for lecturers without a technical background [40]. In addition, there is a shortage of published research on the most effective designs and costs for VR teaching technologies, as well as longitudinal research on innovation adoption across entire HE institutions [43]. This lack of knowledge makes it challenging for universities in ASEAN to come to informed decisions about VR technology and justify significant investments.

AI AND SELF-EFFICACY SKILL

AI could enhance student self-efficacy skill by facilitating personalized learning experiences, providing real-time feedback, and fostering metacognition. Firstly, AI can personalize the learning experience, which is crucial for self-regulation. By analyzing vast amounts of data, AI can tailor the learning material based on individual learning styles, pace, and needs [44]. Such personalized learning environments enable students to have control over their learning, contributing to an increased sense of responsibility and self-regulation [45]. Secondly, AI's ability to provide immediate feedback is a powerful tool for self-regulation. Real-time feedback helps students understand their strengths and weaknesses, allowing them to adapt their strategies accordingly [46]. For instance, automated writing evaluation (AWE) tools such as WriteToLearn and Turnitin which has been used widely among students in ASEAN nations [47] prioritise providing feedback that is designed to be practical – to help learners enhance their writing and to encourage higher-order processes such as self-regulated learning [2]. Lastly, AI can foster metacognition which is a core component of self-regulation as it involves monitoring and controlling one's cognitive processes [24]. AI systems can facilitate metacognitive skills by prompting learners to reflect on their learning processes and strategies [46]. AI-powered learning analytics tools can help ASEAN students monitor their learning progress over time by analyzing a student's engagement with the learning material, time spent on tasks, and performance on assessments, providing insights that students can use to evaluate their learning processes and strategies [15], [26], [27], [49].

However, it is essential to underscore that while AI has promising potential, its implementation must be carefully designed and monitored. Some concerns revolve around the digital divide, biased algorithms, ethical considerations, and the risk of over-reliance on technology [2], [50]. As an instance, summative AWE received criticism for awarding students credit for superficial characteristics such as sentence length, even if the text makes no sense – they can be "duped by gibberish" [49]. Most concerning is that the algorithms underlying AWE are sometimes biased, particularly against students from minority groups, probably as a result of varied vocabulary and sentence structure usage. AI like Summative AWE does not address easily accessible 'deep-fake' school and university assignments – essays written by AI technologies that draw on domain expertise while replicating the individual student's writing style, which is really hard to detect [50]. Furthermore, dependence on AI could undermine students' confidence in their abilities if they become too reliant on AI support [51].

CONCLUSION AND RECOMMENDATION

Currently, HE in ASEAN is gradually exploring the largely unexplored potential of AI in domains of teaching, learning, and administrative governance [32], [53], [54]. From the discourse evolving around the advantages and potential hazards of AI to the development of Industry 4.0 critical skills for ASEAN students, it can be seen that despite the prevalent enthusiasm surrounding AI, its practical implications and achievements do not match the hype. This reality might provoke policymakers, educators and experts to re-envision the role of HE institutions in ASEAN to prepare their students with career readiness in Industry 4.0 through AI-driven promotion of global skills.

The advent of AI and automation suggests a stronger link between educational establishments and the industrial sector to keep up with the skill demand of Industry 4.0 will be necessary [14]. The implementation of AI within

HE institutions could significantly improve workforce readiness [54]. Hence, the incorporation of AI to enhance teaching and learning should be considered. Given the growing demand for ongoing skill development, the potential of AI for skill development in ASEAN necessitates investigation.

Both ASEAN countries and HE institutions should consider adopting flexible skills certification programs that validate skills gained outside the conventional educational pathways. The Malaysian Skills Certification Programme serves as an exemplary model in this regard, recognizing workers who have acquired vital workplace knowledge and skills despite lacking formal education [14]. In response to the increased need for new and improved skills, industry-led certification endorsing the progressive mastery of skills by employees becomes indispensable.

Furthermore, the relevance and adaptability of educational curricula to evolving skill demands must be ensured. Curricula, spanning from primary to tertiary education, must align with the emerging needs of a 4IR economy, encapsulating both technological and soft skills such as creativity and problem-solving [55]. Additionally, HE institutions need to identify and implement policies to prevent the misuse and abuse of AI. Furthermore, collaboration among ASEAN countries, perhaps through its education arm, the ASEAN University Network (AUN), is essential to harmonize AI standards, share best practices, and address regional challenges effectively.

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A FRAMEWORK FOR SUSTAINABLE LEARNING IN INDIAN HIGHER EDUCATION INSTITUTIONS

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ABSTRACT

According to the Declaration of Human Rights, all deserving students must have equal access to higher education, regardless of merit. Upholding the right to education, tertiary education ought to be accessible to everyone, devoid of discrimination, using suitable methods, based on individual abilities, and progressively liberated. Considering that talent exists uniformly across populations, irrespective of their traits, students who have the ability to excel in higher education can be found in all settings. This paper proposes a methodology to ensure effective learning for all types of learners including advanced and slow learners. Proposed approach try to provide unbiased and machine intelligence feedback rather than human to avoid any kind of influence and to maximize the learning and making it self sustainable in long run for every stakeholder. Sustainable Development Goal 4 is about quality education and is among the seventeen Sustainable Development Goals established by the UN in September 2015. The title of SDG 4 is "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all". SDG 8 is about achieving productive and full employment and decent work for all men and women by 2030, including for young people and persons with disabilities, and identical pay for work of equal value.

Keywords: inclusivity; equity; sustainable learning; higher education; machine intelligence

INTRODUCTION

Universal Education has always been a vital component of the goal of sustainable development. In 2014, the Global Education for All Meeting (GEM) proposed SDGs developed by the Open Working Group (OWG) of the UN General Assembly on SDGs targets for the agenda after 2015. "Ensure inclusive and equitable quality education and promote life-long learning opportunities for all" is the proposed SDG #4, along with several related objectives [1]. Higher Education worldwide should consider the guidelines and policies proposed by SDG 4. In India, the Thorat Committee was formed in India in the year of 2007 to confront the prejudice and unequal behaviour experienced by “Dalit” and other disregarded students within HEIs. Although statutory safeguards aiming for equal opportunities, Dalits often confront caste-based bias, degradation, and segregation [2]. Studies in [3] and [4] reveal that Dalit students encounter discrimination, often facing the assumption that they lack the intellectual capacity to manage the challenges of higher education. This misconception has contributed to a rise in suicide rates among Dalit students. Starting in 2009, the Right to Education Act mandated reserved spots for economically disadvantaged and weaker sections. However, due to controversies surrounding these policies, the Supreme Court of India limited reservations to 50% of all jobs and university positions [5].

Inclusive Education can be interpreted as a system of Education that encourages and accepts learning for all students, regardless of their skills, identities, or needs. This entails ensuring that the instruction, curriculum, transportation, facilities at school, areas for paly, and restrooms are suitable for all students at all stages. All students receive an IE, which means they attend the same schools. Nobody ought to be left out. Equity in Education, however, focuses on providing the support according to the need to level out relative disadvantage and support a student who needs it most. Therefore, higher education institutes should address disparities, promote inclusive Education, and ensure Equity in Education, which are essential for meeting global educational goals and fostering a more just and sustainable future. The journey towards a comprehensive and equitable education system requires continued collaboration, dedication, and a shared commitment to providing quality education for all [6].

PROPOSED METHODOLOGY

The conventional approach of the "one size fits all" education system has faced considerable criticism due to its inability to accommodate the diverse needs of individual students. There has been a global shift towards a more personalized, student-centric model, supported by advancements in technology such as Big Data, Machine Learning, and Artificial Intelligence (AI). These technologies enable the customization of education to suit the unique characteristics of each learner. In [7] the paper conducted a systematic review of literature from 2019 to 2021, focusing on education in China, India, and the USA. These countries are considered leaders in Educational Technology (EdTech) innovation, making insights from their research particularly valuable for global educational reform efforts. The findings emphasize the success of AI in tailoring learning experiences to individual needs, habits, and abilities across these nations. Moreover, AI assists in optimizing learning paths and enhancing educational content, while also identifying potential learning obstacles.

Despite the promise of personalized education facilitated by AI, there are challenges to its widespread adoption. Concerns include issues related to data privacy, the availability of digital resources, and affordability constraints, all of which may hinder the seamless integration of AI into everyday educational practices. In summary, while AI presents significant opportunities for the future of education by offering personalized learning experiences, addressing associated challenges is crucial to ensure equitable access and effective implementation of these technologies.

In our proposed approach, we are advocating the following [8], [9]:

- An educational approach that's fully tailored to students' individual abilities and needs could directly increase their motivation and reduce their likelihood of dropping out.
- Regular and structured feedback to instructors and the learning ecosystem for appropriately assessing an individual's need/s (slow learners need more tutoring whereas advanced learners need to have more challenging assignments)
- Virtual (non-human) TA, counsellors
- A virtual student to objectively measure learning outcomes - if the virtual student is learning, so are the other students.
- The virtual student can be configured as a slow learner, an advanced learner or an average learner.
- A robot (virtual teacher, counsellor etc.), with customized configurations to match students' profiles, shall be provided by a Higher Education Institution to each student.
- All informative and common interactive sessions could be covered by the virtual teacher.
- Outcomes like hours spent for learning, honesty and integrity in quizzes and assignments, retaking of sessions, could be reported to instructors and administrators' dashboards.
- Freedom to learners in terms of language, pace of learning, timing and also teachers.

CONCLUSIONS

It is very imperative that to achieve SDG 4 and to have learner centric approaches, technology is one of the most appropriate ways to move forward, given that technology has inherent characteristics of sustainability which are free from biases. Further, authors of the paper advocate that personalized learning and machine-based feedback with modern system design approaches using large language models and other deep learning solutions are some of the best ways forward.

ACKNOWLEDGEMENTS

This extended abstract is part of an ongoing project entitled “Fostering Inclusive and Equitable Quality Education to stimulate lifelong sustainable learning opportunities for HEIs in India”, (Acronym: InEq-SI; Erasmus+ CBHE Strand I; Project No. 101082909) which is co-funded by the European Union, and involves four Indian and two European Higher Education Institutions. The authors used ChatGPT in order to improve readability. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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INFUSION OF SUSTAINABILITY INTO THE CURRICULUM OF HIGHER EDUCATION INSTITUTIONS IN CHILE.

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ABSTRACT

This study seeks to explore the perceptions and strategies concerning the infusion of sustainability in higher education among Chilean lecturers who are part of a national sustainable campus network (*n*=61). Data were collected through an online self-administered questionnaire. Three primary dimensions were explored: Competence approach, Silo approach, and Lecture training. Findings revealed a widespread consensus regarding the significance of incorporating sustainability-related competencies into curricula, although variations existed in preferred strategies for achieving this goal. The study underscored the necessity for enhanced lecturer training in sustainability content and advocated for the inclusion of sustainability criteria in assessment systems. By offering an in-depth analysis of current perceptions and practices, this research contributes to a comprehensive understanding of the challenges and opportunities associated with infusing sustainability into higher education.

Keywords: sustainability development; active learning; curriculum; transformative change; higher education.

INTRODUCTION

In recent years, the debate surrounding the most effective approach to integrate sustainability into university curricula has intensified. One approach advocates for the infusion of sustainability principles across existing courses, emphasizing interdisciplinary collaboration and holistic understanding [1], [2]. In spite of recognizing its importance, evidence suggests that the integrated approach remains weakly implemented within educational systems [3]. Thus, the infusion of sustainability principles into higher education curricula is paramount for fostering a sustainable future. However, this endeavor has its challenges and complexities [4].

In fact, achieving successful integration of sustainability in higher education necessitates a transition from emphasizing teaching to prioritizing learning, along with adopting a multidisciplinary approach that encompasses the environmental, economic, and social dimensions of sustainability [5]. However, numerous obstacles exist at various levels that hinder the successful contribution of Higher Education Institutions (HEIs) to sustainability effort, mainly, disciplinary silos and lack of lecturer training [2], [5]. Without addressing these challenges and enacting fundamental changes within the academic realm, universities could lose their pivotal role in research, knowledge dissemination, and be incapable of shaping future leaders equipped to tackle sustainability challenges.

As a result, disciplinary silos persist firmly entrenched, with individuals primarily recognizing value solely within their respective disciplinary boundaries [6], [7]. Rather than operating in isolated silos. collaboration and learning from colleagues who specialize in other disciplines are essential for integrating sustainability issues effectively [2]. To understand this concept, 'the term silo' originates from grain silos, which separate different types of grain [5]. Thus, it serves a metaphor for the segregation between various disciplines or departments within a Higher Education Institution (IES). This entrenched perspective limits interdisciplinary collaboration and hampers the ability to appreciate the contributions and insights offered by other fields.

In contrast to the European context, the majority of Chilean IES has leaned towards a disciplinary or silo approach, where sustainability is addressed, in a fragmented manner [2], [5,] [10] through specialized courses that do not facility a more holistic approach to integrate sustainability in Higher Education [6], [8] [9].

Unfortunately, this approach falls short of infusing sustainability as a cross-cutting competence throughout the curriculum - a key aspect advocated by the competence approach. By failing to engage all faculty members in active learning methodologies centered on sustainability, universities could miss the opportunity to cultivate a broad understanding and application of sustainability principles among students.

METHODOLOGICAL STRATEGIES FOR INTEGRATING SUSTAINABILITY

Below are some methodological strategies for infusing sustainability in a comprehensive and holistic manner:

- *Infusion of sustainability themes across all courses:* Incorporate concepts, such as, systems thinking, energy flow, cycles, natural resources, interactions, flourishing, cultural influences, and resilience (Figure 1). It is also recommended to give examples and cases related to sustainability in all subjects, regardless of their discipline. This strategy may include discussions on current environmental, social, and economic issues, as well as sustainable solutions that fit into different disciplines.

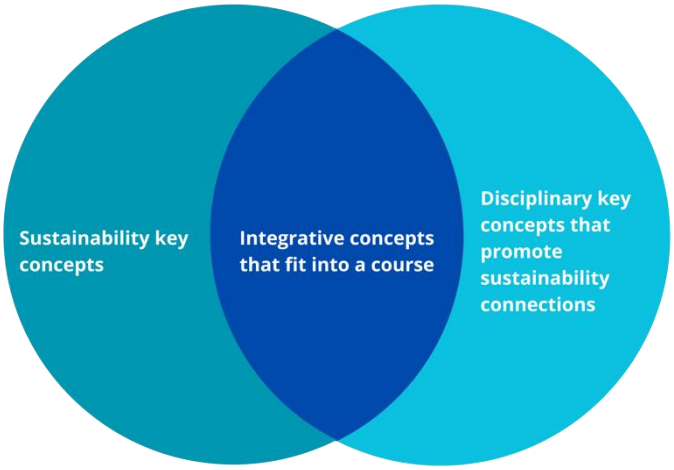

Figure 1: Curricular integration of sustainability key concepts

- *Development of generic competencies:* Design active learning activities that foster critical thinking, problem-solving, teamwork, and effective communication, with a focus on applying these aspects to sustainability challenges. These competencies should be integrated in all university curricula. This strategy may be implemented through learning outcomes that contribute to the meta-profile of all higher education programs, including specific and generic competencies.
- *Interdisciplinary projects:* Encourage projects that require collaboration between different disciplines to address complex sustainability issues. This strategy allows students to see how various fields of knowledge can contribute to comprehensive solutions. This strategy may include Project Based Learning (PBL), Service-Learning (S+L), and Collaborative Online International Learning (COIL)
- *Hands-on experience*: Organize practical activities such as field projects, internships, or community service programs, where students can apply sustainability concepts learned in the classroom to real-world situations, thereby contributing to a positive change in the community. Learning by doing, as a prominent aspect of experiential learning, emphasizes the value of practical, hands-on experiences in the learning process [
- *Use of technology and multimedia resources*: Utilize technological tools and multimedia resources to create interactive and engaging learning experiences on sustainability. This may include simulations, role-playing games, educational videos, and Artificial Intelligence (AI) tools for sustainable development.
- *Promotion of reflection and action:* Foster critical reflection on values and attitudes towards sustainability, as well as motivation for individual and collective engagement and action to address environmental and social challenges. Exploring sustainability as flourishing is highly recommended.

By implementing these strategies, effective infusion of sustainability into the curriculum can be achieved, providing students with the skills and knowledge necessary to address current and future challenges in a holistic and sustainable manner.

MATERIALS AND METHODS

The objective of the research was to explore the perceptions and strategies concerning the infusion of sustainability among Chilean lecturers. For this purpose, the researcher employed a quantitative method, with a non-experimental, descriptive design.

Participants

Participants were eligible for the study if they were members of a Chilean sustainable campus network and were lecturing in national HEIs. The sample of the study consisted of 61, 49 men (80.3%) and 12 women (19.7%), with an average age of 51 (SD = 8.4). Participants completed a self-administered questionnaire through a WhatsApp group.

Instrument

Data was collected through a questionnaire consisting of 15 closed-ended questions, with values ranging from 1 = Strongly Disagree to 5 = Strongly Agree. This instrument was validated by a panel of expert judges and then refined based on the feedback received. For analysis purposes, the questionnaire has been organized into three dimensions: *Competence approach, Silo approach* and *Lecturer training*. The self-administered questionnaire was completed through a WhatsApp group managed by a sustainable campus network that aims to promote sustainability in higher education in Chile.

RESULTS

Table 1 presents the findings of a survey aimed at exploring the perceptions of lecturers regarding the infusion of sustainability into the higher education curriculum. The survey comprised 15 questions designed to evaluate different facets of sustainability infusion and its influence on student engagement in active learning. The mean and standard deviation values offer insights into the average ratings provided by participants and the degree of consensus or variability in their responses.

Table 1 – Survey results. Source: own elaboration.

Questions	*n*	Mean	SD	α
1. Sustainability should be infused, as a cross-cutting competence, by lecturers, in all disciplines and degrees.	61	4.98	0.13	0.81
2. Introduction to Sustainability should be a mandatory course in all curricula.	61	3.33	1.47	0.79
3. Generic competencies, such as teamwork, problem-solving, and others, help to infuse sustainability into the curriculum.	61	4.72	0.49	0.78
4. To infuse sustainability into the curriculum, it is necessary to reinforce system thinking and holistic approach in teaching practice.	61	4.52	0.89	0.79
5. It is necessary to include sustainability competencies in undergraduate and postgraduate curricula.	61	4.70	0.49	0.75
6. Sustainability should be infused in the curriculum through specific courses by specialists.	61	3.44	1.42	0.78
7. From a comprehensive approach, it is necessary to include sustainability criteria in assessment systems for learning.	61	4.20	1.24	0.78
8. Lecturer training in sustainability content is key to its inclusion in teaching practice.	61	4.64	0.66	0.75
9. To generate an attitudinal change, it is critical to introduce sustainability through active learning strategies.	61	4.67	0.68	0.70
10. Extra-curricular sustainability can be complemented through student training in the form of seminars, service-learning, etc.	61	4.49	0.65	0.80

Questions	*n*	Mean	SD	α
11. It is necessary to leave space in the curriculum to include subjects on sustainability.	61	3.75	1.04	0.78
12. Mechanisms of social interaction are needed to enhance the role of Higher education in achieving sustainable development.	61	4.74	0.51	0.81
13. To generate an attitudinal change, it is critical to introduce sustainability through specialized courses in the curriculum.	61	3.61	1.11	0.78
14. Sustainability, as a competence, involves stimulating creativity, critical thinking, reflection, and self-learning in students.	61	4.67	0.68	0.78
15. Sustainability, as a competence, involves integrating technical concepts in disciplinary subjects.	61	3.98	0.79	0.78

The results of the study show that Cronbach's Alpha is quite high: 0.80 for the 15 items. They also reveal a mixed perspective on the integration of sustainability into higher education curricula. On one hand, there is strong support for the idea that sustainability should be incorporated as a cross-cutting competence across all disciplines, as indicated by the high mean score of 4.98 for Question 1. Similarly, there is recognition of the importance of including sustainability competencies in undergraduate and postgraduate curricula, as evidenced by the mean score of 4.70 (Question 5). Implementation of active learning strategies is also perceived as relevant for sustainability infusion, as shown by the mean score of 4,67 (Question 9). Moreover, lecturer training in sustainability content (Question 8) is highlighted as crucial for its effective inclusion in teaching practice, with a high mean score of 4.64 for Question 8. These findings suggest a widespread acknowledgment of the significance of sustainability education in higher learning institutions.

On the other hand, there are areas where the survey responses indicate room for improvement. For instance, the relatively low mean score of 3.33 for Question 2, regarding the integration of sustainability as a mandatory course in all curricula. Overall, while there is evident recognition of the importance of sustainability education, these results highlight the need for further exploration and consensus-building to effectively integrate sustainability principles into higher education curricula. Table 2 shows the summarized results of the study, according to the dimensions defined by the researcher.

Table 2 – Summarized results by dimension. Source: Own elaboration.

	Competence approach	Silo approach	Lecturer training
Mean	4.53	3.51	4.55
Standard deviation	0.79	1.26	0.81
Cronbach's Alpha	0.79	0,79	0.78

The results in Table 2 reveal contrasting perspectives among lecturers regarding sustainability integration into higher education curricula. While there is strong agreement on the importance of interdisciplinary infusion, reflected in the *Competence approach* (M= 4.53; SD= 0.79; α=0.79), some lean towards a more disciplinary *Silo approach* (M= 3.51; SD= 1.26; α= 0.78**)**. Additionally, the emphasis placed on *Lecturer training* highlights its crucial role in curriculum integration (M= 4.55; SD=0.81; α= 0.78). However, the variability in responses suggests the need for further exploration and targeted interventions to address underlying concerns.

CONCLUSIONS

The results of the study present a nuanced view of the integration of sustainability into higher education curricula among university lecturers. While there is strong consensus on the importance of incorporating sustainability as a cross-cutting competence across all disciplines, including, undergraduate and postgraduate curricula. Evidenced by high mean scores, some areas require attention and improvement. The

relatively low mean score for the necessity of an introduction to sustainability as a mandatory course in all curricula suggests a lack of consensus on this approach, while lower scores for allocating space in the curriculum for sustainability subjects and introducing specialized courses indicate potential challenges or resistance. The summarized results in Table 2 highlight the discrepancy between the Competence approach, emphasizing interdisciplinary integration, and the Silo approach, advocating for more compartmentalized methods. In addition, the findings underscore the importance of Lecturer training in sustainability content while also indicating a need for further exploration and consensus-building to effectively integrate sustainability principles into higher education curricula.

ACKNOWLEDGEDMENTS

Acknowledgment. The author acknowledges the voluntary participation in this study of colleagues belonging to a sustainable campus network in Chile. The author used ChatGPT to check grammar issues and to improve readability. After using this tool, the author reviewed and edited the content as needed and take full responsibility for the content of the publication.

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INCLUSIVE AND EQUITABLE EDUCATION TO STIMULATE LIFELONG SUSTAINABLE LEARNING IN INDIA – A STEP TOWARDS ACHIEVING THE SUSTAINABLE DEVELOPMENT GOALS

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ABSTRACT

The idea of complete growth is based on the perception of equality of opportunity. This demands that deserving students from all social groups be provided with sufficient opportunities for self-development. The Sustainable Development Goals (SDGs) adopted at the UN Sustainable Development Summit in New York in September 2015 are a blueprint to achieve a better and more sustainable future for all. They address the global challenges we face – poverty, inequality, climate change, quality education, environmental degradation, peace, and justice. All goals are interconnected, and to ensure that no one is left behind, we must achieve them all by the end of this decade. However, upon looking at the yearly reports as part of the implementation of the SDGs, a disappointing reality emerges: the world is falling short of meeting most of the Goals by 2030. Given this fact, a consortium of six higher education institutions from India and Europe began to work for inclusive and equitable education in India as a step forward to achieve specific Goals, with co-funding from the European Union under the Erasmus+ Program's Capacity Building in Higher Education (CBHE) action Strand I. This extended abstract details the milestones achieved through collaboration.

Keywords: Inclusive Education; Equitable Education; Collaboration; Sustainable Development Goals; India.

INTRODUCTION

The 2030 Agenda for Sustainable Development, adopted by all UN Member States in 2015, provides a blueprint for prosperity and peace for people and the planet, now and into the future. [1] There are 17 SDGs, which are an urgent call for action by all countries in a global partnership and are the focus point of the agenda. Strategies that improve the quality of education and reduce inequality are among those highly recognized and prioritized areas to focus on along with other areas such as ending poverty and other deprivations, and spurring economic growth while tackling climate change and working to preserve our oceans and forests. To assess the progress in implementation, every year, the UN Secretary-General presents an annual SDG Progress Report based on the global indicator framework and data produced by national statistical systems and information collected at the regional level. A multi-university collaborative research project among six international higher education institutions and universities was initiated in April of 2023 with the objectives of "Building the capacity of Higher Education Institutions (HEIs) in India by establishing Teaching and Learning Centers (TLCs) for making education more equitable and inclusive using digital technology for all". The prominent SDGs that form part of this important initiative include Goal 4 – "Quality Education for All" – and Goal 8 – "Decent work and economic growth".

SUSTAINABLE DEVELOPMENT GOALS REPORT 2023

As per SDG Report 2023: Special Edition – *towards a rescue plan for people and the planet*, five key areas are identified for urgent action. [2] The second key area among these five is: "*Governments should advance concrete, integrated and targeted policies and actions to eradicate poverty, reduce inequality and end the*

war on nature, with a focus on advancing the rights of women and girls and empowering the most vulnerable." It requires quick action to meet the SDGs which "*requires the following: giving meaning to the commitment to leave no one behind by expanding social protection floors and access to essential services; creating job opportunities in the care, digital and green economies; urgently tackling the profound crisis in education; strengthening action to advance gender equality, leveraging digital technologies to close divides; supporting the inclusion of persons displaced by crises; and tackling the exclusion of marginalized groups, such as persons with disabilities.*" Some of the findings observed from the SDG progress report 2023 (progress made at the midpoint) particularly for SDGs 4 and 8 are as follows:

(1) Overall progress for SDGs 4 and 8 shows fair progress but an acceleration of about 30% and 40% is required respectively in both goals.

(2) Without additional measures, only one in six countries will achieve the universal secondary school completion target by 2030.

(3) To deliver on Goal 4, education financing must become a national investment priority. Furthermore, measures such as making education free and compulsory, increasing the number of teachers, improving basic school infrastructure and embracing digital transformation are essential.

(4) Low levels of Information and Communication Technology (ICT) skills are a major barrier to achieving universal and meaningful connectivity.

(5) Achieving Goal 8 will require a comprehensive reform of the financial system to tackle rising debts, economic uncertainty and trade tensions, while promoting equitable pay and decent work for young people.

(6) Young people aged 15–24 continue to face severe difficulties in securing decent employment, and the global youth unemployment rate is much higher than the rate for adults aged 25 and above.

SUSTAINABLE DEVELOPMENT GOALS: THE INDIAN SCENARIO

As per the dashboard of the Sustainable Development report [3], India is at the SDG Index Rank 112 out of 166 with the SDG index score of 63.45. As seen in Figure 1, the percentage trend is on track or maintaining SDG achievement in Goals 1 & 12, moderately improving in Goals 3-9, 14 & 17, stagnating in Goals 2, 11, 13 & 16, and decreasing in Goals 10 & 15.

Figure 1 – Status of SDG targets for India (% trend indicators). Adapted from [3].

The agenda for global education development reflected in Goal 4 of "*The 2030 Agenda for Sustainable Development*", and accepted by India in 2015, seeks to "*ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*" by 2030. The NITI Aayog (National Institution for Transforming India) is the nodal institution for achieving SDGs in India, leading the 2030 Agenda with the spirit of cooperative and competitive federalism [4]. It has attempted to measure Goal-wise progress primarily based on the outcomes of the interventions and schemes of the Government of India. As per the goal-wise performance published by NITI Aayog [5] and illustrated in Figure 2, performance in nine goals has improved, has seen no change in two, and has dropped in five. Two out of five goals in which the performance dropped are SDGs 4 and 8 – the target goals for the project taken up by our consortium.

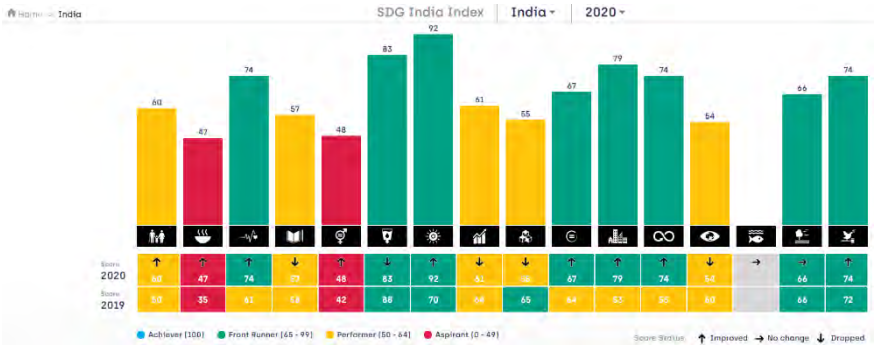

Figure 2 – SDG India Index. Adapted from [5].

The major grounds for exclusion in India are region, religion, caste, gender, economic disparities, and disabilities. Therefore, strategies for achieving inclusive growth necessarily need to include affirmative policies targeting the socially disadvantaged, marginalized, economically poor, and people with disabilities.

Thus, it is essential to focus on Goals 4 and 8. With that in mind, four Indian higher educational establishments (three universities and one HEI) – CVM University (https://www.cvmu.edu.in/), Sarvajanik University (https://sarvajanikuniversity.ac.in/), Ganpat University (https://www.ganpatuniversity.ac.in/) and D.Y. Patil College of Engineering and Technology (https://coek.dypgroup.edu.in/) jointly decided to build the capacity of higher education institutions in India to "*Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*". These four Indian educational establishments formed a consortium with two European Universities – Universidad Politécnica de Cartagena (https://www.upct.es/) and Riga Technical University (https://www.rtu.lv/en) – to work jointly to achieve the UNSDGs 4 and 8 in the project.

A STEP TOWARDS ACHIEVING UNSDGS 4 AND 8

The consortium under the coordination of Sarvajanik University had applied to the European Commission to receive a grant under the CBHE-Strand-I of the Erasmus+ Program, with a project entitled "*Fostering Inclusive and Equitable Quality Education to stimulate lifelong Sustainable Learning Opportunities for HEIs in India*".

The project got approval from the European Commission on September 29, 2022, and the consortium has been working on the project since April 1, 2023. It aims to increase the accessibility of higher education in India for students with fewer opportunities and provide a framework for equity and inclusion in the Indian HEI ecosystem. It would also cater to the challenges for teaching and teachers, and recommend policy measures for establishing higher education systems that are more equitable and more inclusive. By relying on digital technology and e-learning for vulnerable students, the project will develop a remote and inclusive learning pathway. The project's target objectives are: 1. Identify the best remote and inclusive learning pathways and opportunities for Higher education; 2. Develop an inclusive Methodology and Curriculum Framework for accomplishing the education SDGs to provide sustainable learning; 3. Digital technology for inclusiveness of educational learning; 4. Establishing a Teaching and Learning Centre (TLC) at each target HEI. During the project, the consortium will have learnings to adopt an equitable and inclusive higher education system for students from diverse backgrounds.

The implementation of the project is sub-divided into three strategies – **First Strategy: Establish a Foundation** – Work Package (WP) 1 is designed to create a foundation for the project; **Second Strategy: Create a Platform** – WP2 is designed to identify and implement inclusive methodologies and curriculum; and the **Third Strategy: Implement** – WP3 through WP7 are designed for efficient implementation of a digital platform with Innovative teaching and learning methods concerning inclusive and equitable higher education based on the foundation established in WP1. The project is scheduled for implementation by the end of March 2026, with outcomes being measured and reported for a further three years. The project timeline is in line with the target set by the UN and accepted by India, i.e. to achieve the UNSDGs by 2030.

At present, the following activities have been undertaken to foster inclusive and equitable quality higher education to stimulate lifelong sustainable learning opportunities for HEIs in India.

(1) Four-week training at Universidad Politécnica de Cartagena to understand various perspectives of inclusive and equitable education and decide the methodology to implement in the Indian HEI ecosystem.

(2) A detailed report on the global perspective of inclusive and equitable higher education and an exhaustive report on the Indian perspective on inclusive and equitable higher education has been prepared and submitted for review to the European Commission.

The consortium is working on developing inclusive and equitable teaching-learning methodologies and strategies, defining the areas, courses, and skill development programs along with appropriate curricula, and their implementation using universally accessible means, including remote technology.

CONCLUSION

Vincent Van Gogh once said, "*Great things are not done by impulse, but by a series of small things brought together.*" The importance of small steps cannot be overstated. They help us break down larger goals into more adaptable objectives, build momentum towards our goals, reduce our fear of failure, and ultimately achieve greater success. The effort of the consortium towards fostering inclusive and equitable quality higher education to stimulate lifelong sustainable learning opportunities for HEIs in India is a vehement step towards achieving the Sustainable Development Goals.

ACKNOWLEDGEMENTS

The extended abstract is a part of the project entitled "*Fostering Inclusive and Equitable Quality Education to stimulate lifelong Sustainable Learning Opportunities for HEIs in India*" (Acronym: InEq-SL and Project No. 101082909) which is co-funded by the European Union.

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A SUCCESS MODEL FOR RETENTION OF WOMEN IN STEM HIGHER EDUCATION

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ABSTRACT

Nations worldwide are investing millions of dollars in encouraging educators to implement measures that increase the number of women who pursue STEM education. However, the higher education sector has yet to respond aggressively to these calls. Despite such efforts, the percentage of women graduating in STEM has remained stagnant over the past decade, indicating a need for further research to identify strategies to support women's retention in STEM. This study aimed to investigate factors influencing women's persistence in STEM higher education and identify strategies for improving their retention. The systematic literature review conducted using PRISMA guidelines identified five major categories of factors - sociocultural, psychological, supportive, environmental, and pedagogical - that could positively or negatively impact women's persistence in STEM studies. The findings indicate that knowledge of these factors can create a fertile ground for women's successful persistence in STEM education. While several studies have explored this topic and identified some of these factors separately, this study is the first to bring all these major factors together to build a powerful framework for retaining women in STEM studies. The study presents a framework, "A success model for retaining women in STEM higher education," and recommends powerful retention strategies.

Keywords: STEM women; higher education; PRISMA; systematic literature review; retention.

INTRODUCTION

Retention of women in Science, Technology, Engineering and Mathematics (STEM) higher education is a topic of worldwide interest. In this globally competitive world, producing more STEM degree holders is essential for the nation's industrial and economic growth. Despite governments worldwide spending millions of dollars to increase the number of women in STEM, they remained a minority over the past 20 years. This points to the necessity of further research to identify strategies for increasing the number of women in STEM. Hilts et al. [2] documented that a lack of sufficient STEM degree holders leads to a shortage of essential skills and slows the growth of industries. The authors state that any economy must capitalise fully on the STEM potential of its students [3]. The lack of women's participation in STEM education intensifies the problem of skill shortages in the STEM workforce. Moreover, studies have illustrated a strong business case for gender diversity. According to a study by the Grattan Institute, increasing the number of women in the workforce by 6% could add up to $25 billion to Australia's economy. Gender-diverse companies have been found to outperform their counterparts by 15% financially [4]. There is a strong correlation between gender diversity in leadership with higher returns, profitability and share prices [5]. More gender-diverse teams produce better results.

Developing an education system that can enhance the representation of women STEM workforce is necessary. A systematic literature review (SLR) was conducted to determine the factors influencing the persistence and retention of women in higher education STEM programs. The issue of retaining women in STEM has garnered significant attention in previous research, with discreet discussions on several factors that contribute to the problem. Despite these efforts, the percentage of women graduating from STEM has plateaued over the last ten years, highlighting the need for further exploration of effective strategies. As such, this study aimed to consolidate and classify these factors into a framework that can serve as a basis for

retaining women in STEM higher education. The findings of the SLR can be utilised to design and implement strategies that promote the advancement and retention of women in the STEM. The research question for this study was formulated as follows:

'What factors positively or negatively influence the persistence and retention of women in STEM higher education?

METHODOLOGY

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol guidelines and flowcharts have been utilised for this SLR. PRISMA guidelines include a 27-item checklist and a four-phase flow diagram [6] that define the accepted practices for conducting SLR. Electronic databases IEEE, Scopus, and ScienceDirect were searched for the data collection. Google Scholar was used as a complementary database. Table 1 shows the search terms and initial search results. The search terms were used to find articles closely correlated to the research question. While every attempt has been made to find all possible articles matching the selection criteria, articles may inadvertently have been overlooked. Finally, thirty articles were selected for the SLR after applying strict inclusion and exclusion criteria. A PRISMA Flow Diagram depicting the article selection process has been created and can be accessed as a supplementary document 1 to this paper. An Excel spreadsheet stores the data extracted from the articles (supplementary document 2). The data included the articles' research purpose, research design, participants' demographics, key findings and major and minor themes. In addition, all papers were stored in Mendeley[1] for future reference.

Table 1: Database Search Results.

Search Terms	Database	Search Limiters	Hits
("Woman" OR "Women" OR "Women students") AND ("STEM studies" OR "STEM education") AND ("Persistence" OR "Retention" OR "Engagement") AND ("Higher education" OR "Tertiary education").	IEEE	Journals Published: 2010 - 2022	44
	ScienceDirect	Research Articles Published: 2010 - 2022	57
	Scopus	Journal Articles English Published: 2010 – 2022 Sorted by: Cited by highest Publication stage: final Keywords: STEM, GENDER, Higher education, Women	168
	Total		270

Braun & Clarke's [7] thematic analysis technique was used to extract themes from the selected articles. A theoretical thematic coding approach was chosen for this study to obtain a detailed analysis of the specific aspect of the data, identifying factors that impact the persistence of women in STEM education. The selected articles were scrutinised to identify texts that correlated to the persistence of women in STEM and recorded in an Excel spreadsheet for analysis (supplementary document 3).

THEMES

In the first phase of our thematic analysis, we have identified forty-five initial themes that are relevant to our research focus. In the second phase, we have employed Wang & Degol's [8] theoretical model to classify these themes into five primary categories. The preliminary themes that lacked meaning or relevance were

[1] Mendeley is a reference manager that can help you store, organise, note, share and cite references and research data.

combined or eliminated to define major themes [7]. The five major themes were psychological, sociocultural, supportive, environmental and pedagogical.

Psychological factors that affect the persistence of women in STEM are their competence, beliefs, goals, interests, and values [9]. The SLR identified several psychological factors, including a sense of belonging, STEM identity, self-efficacy beliefs, fixed/growth mindsets, motivation, perceived cost, and career outcome expectations (COE). Sociocultural factors stem from cultural norms, values, and beliefs that are deeply rooted within students, instructors, and society at large. In the chosen articles for this SLR, sociocultural factors were examined, including cultural and gender stereotypes, bias, masculinity and femininity, sexism, microaggressions, and communal goal beliefs. The support that women receive from their social networks will undoubtedly help them face setbacks in traditionally male-dominated fields. This research paper has identified and proposed the factors that can help women to persist in STEM education. The “supportive” factors are subcategorised into four groups: a). Support groups comprise peer mentoring, academic support groups, academic advisors, mentorship, and social support; b). Interpersonal relationships include peer contact, instructor care, and student-faculty interaction; c). Role models; and d). Interventions. STEM classroom environments are sometimes different for men and women [9]. The treatment of women in STEM environments can be described as a "chilly climate" [10]. This encompasses both explicit actions, such as directing women to change their majors or questioning their intellectual capabilities, and subtler actions, such as interrupting women during speaking engagements or giving male students more opportunities to contribute. Pedagogy plays a crucial role in generating enthusiasm and retaining women in STEM studies as research has shown that instructors' pedagogical and behavioural choices significantly impact learners' motivation [11].

A SUCCESS MODEL FOR RETENTION OF WOMEN IN STEM EDUCATION

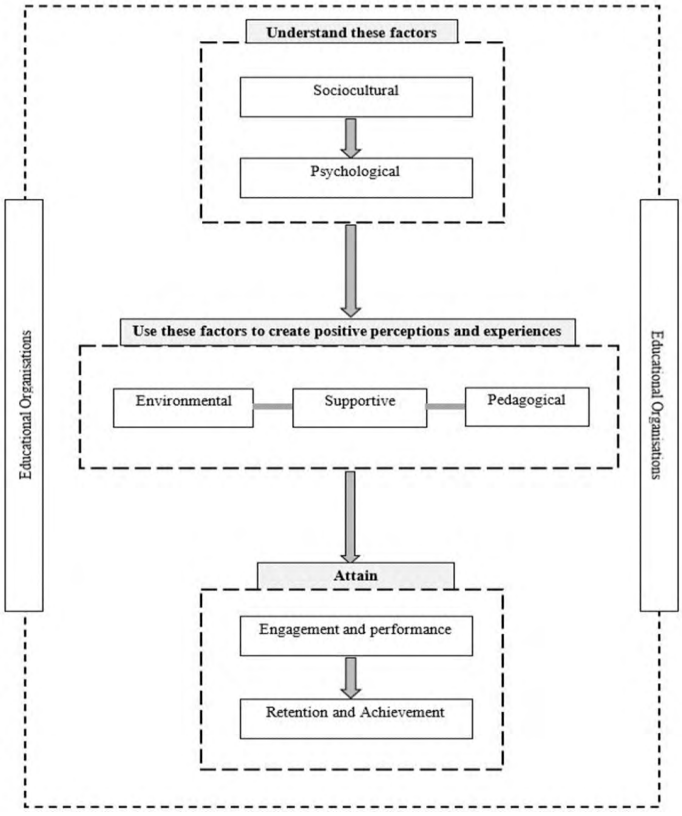

Figure 1 – A success model for retaining women in STEM education.

The present study comprehensively analysed numerous factors influencing women's persistence and retention in STEM higher education. Synthesising the data collected, we have developed a model emphasising the interplay between psychological, sociocultural, supportive, environmental, and pedagogical factors and their impact on women's success in STEM fields (Figure 1). To enhance women's persistence in STEM higher education, the model proposes a two-step process: understand sociocultural and psychological factors in any specific context and leverage environmental, supportive, and pedagogical factors to foster positive psychological impact. By reshaping the STEM fields to foster positive experiences and perceptions, academic engagement and performance can improve, leading to increased retention and achievement of women in STEM fields [9].

CONCLUSION

The SLR identified and categorised factors substantially impacting women's persistence in STEM higher education. A success model is proposed to ameliorate the persistence of women in STEM education. Based on this study's findings, two actions are recommended to educational organisations to increase the retention of women in STEM studies. First, institutions are encouraged to utilise the modifiable environmental, supportive and pedagogical factors to create positive STEM experiences and perceptions in women by profoundly understanding the cohort's specific baleful sociocultural and psychological challenges. This can lead to better academic engagement and performance, which are proven predictors of the retention and achievement of women. The findings of this research have significant implications for universities and other STEM-focused institutions concerned with the high attrition of women STEM students.

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EXPLORING STUDENT'S PERCEPTIONS OF STATISTICS COURSE AMONG ENGINEERING UNDERGRADUATES: A QUANTITATIVE STUDY

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ABSTRACT

Statistics is a branch of mathematics that deals with data analysis and holds a crucial role in engineering, offering vital tools for handling data in diverse contexts. It is useful for students in figuring out how to collect data properly, analysing it to find patterns, or making decisions based on what the data shows. The study explores engineering undergraduates' perspectives regarding the various aspects that affects their statistics course learning and association between a student's prior knowledge in statistics and their perception of the subject's difficulty. The study explores the perspectives of 43 undergraduate engineering students through survey questionnaires. The findings reveal generally positive perception among students towards both the statistics lecturer's role and the subject of statistics itself. Most of the students have good perception toward statistics with (90.7%) rated excellent or good that the lecturer was well organized for the class session. There were (69.8%) rated excellent or good for the statement that statistics learning materials provided by the lecturer contributed to their learning. There were 44.2% of students find statistics subject challenging, A *p*-value of < 0.05 was set as the cut-off for statistical significance. It was found that there is no significant difference between students' prior knowledge in statistics and their perception of statistics as challenging as indicated by p-value of 0.782. Despite these challenges, students acknowledge the importance of statistics in their future professions, emphasizing its significance beyond academia. Overall, the research suggests a positive outlook towards statistics among engineering students, with opportunities for targeted improvements to better meet their diverse needs, enhance learning outcomes, and increase relevance to their chosen fields.

Keywords: statistics, engineering undergraduates, student perceptions, lecturer role, survey

INTRODUCTION

Statistics is the branch of mathematics which associates the study of collection, analysis, interpretation, and organizations of data. Statistical knowledge will help learners to deal with every aspect of data which enables them to choose the proper method of data collection and analysis to produce effective results. Most of the undergraduate majors require a statistics course as a pre-requisite or in fulfilment of general education requirements. Teaching and learning statistics are are becoming an increasingly important part of higher education (de Oliveira Júnior et al. (2018). By integrating statistics education into undergraduate curricula, universities and colleges aim to provide students with a foundational understanding of statistical concepts and data analysis techniques.

These courses play a vital role in developing students' ability to analyse and interpret data, a critical skill for making informed decisions based on evidence and trends. Therefore, it is an important field in engineering to showcase the students on how statistical techniques such as control charts, hypothesis testing and process capability. Students can learn how statistical methods help identify defects, imporove produc quality, and optimize manufacturing processes. The central role of statistics knowledge is important to engineering students in analysing and interpreting data and critically reviewing evidence.

Additionally, for those considering further academic pursuits or research, a solid grasp of statistics is fundamental for designing experiments, collecting data, and drawing meaningful conclusions from research findings.

The skills and abilities developed during research assignments are not only essential for completing their academic tasks, but also have a significant impact on their future careers as they engage in ongoing research, educators are expected to continuously enhance the quality and effectiveness of their teaching (Ado, 2013; Tack & Vanderlinde, 2014).Statistics can be perceived as a challenging subject, and some students may experience anxiety related to dealing with numbers and data analysis. Hence, it can cause slow learning and problem-solving abilities among the students. Statistics is often perceived as challenging and intimidating due to its complex concepts, difficulty in comprehension, and the challenging nature of assessments (Asmat et al., 2015).

Male and Lumbantoruan (2021) stated that the students who are motivated to learn statistics are more likely to put in the effort and time required to understand the subject. On the other hand, a lack of motivation can result in a can hinders their learning progress.

Due to its challenging nature, statistics has become uninteresting for many students, leading to demotivation and decreased interest in the subject. This lack of enthusiasm often raises the question of why most undergraduate students have a low proficiency level in dealing with statistics. Students with positive beliefs tend to approach statistics with excitement and enthusiasm, while those with negative beliefs find it difficult and may even show indifference towards the subject (Male and Lumbantoruan ,2021).

Most of the university students often come from diverse backgrounds and experiences in statistics because this subject is not extensively taught in many surrounding and feeder high schools. However, students who undertaking engineering course often has some statistics literacy that has been taught as a part of mathematics course. Understanding students' attitudes towards formal statistics courses is very important due to the resulting variations in their perceptions. Some students may lack confidence and harbour negative feelings towards statistics, while others may only be motivated to pass exams. Research conducted by Gunawan et al. (2020) revealed through their study that students who held optimistic attitudes towards their academic endeavors tended to achieve success, while those with negative perceptions were prone to failure.

Additionally, some students may hold misconceptions about the usefulness of statistics in future engineering practice. Consequently, it is crucial to comprehend these attitudes to tailor teaching methods, enhance motivation, address misconceptions, improve course content, promote student success, and prepare students for future challenges in an increasingly data-driven world. Surveys, focus groups, and one-on-one discussions can be employed to gain insights into students' attitudes and create a supportive learning environment that fosters a positive outlook towards statistics. (Fa Chen , Zhijian Hu, 2021)

Based on the above issues and importance this study had been conducted to explore the perception among engineering undergraduates on aspects that influenced their learning in statistics. Since the lecturer encounter with the issues on providing quality learning to enhance students' learning process and achievement in statistics, the following objectives has been identified.

By analyzing their perceptions in statistics we will be able to identify the barriers and take remedial actions to foster a positive outlook towards statistics.

Aim: The research aims to explore the perception of Undergraduate Engineering students on aspects that influenced their learning in Statistics.

Objectives: The aim of this research will be achieved through the following objectives:

- To explore engineering undergraduates' perspectives and attitude regarding the various aspects affects their statistics course learning,
- Is there any relationship between a student's prior knowledge in statistics and their perception of the subject's difficulty?

METHODOLOGY

In the present study, the data were collected using a cross sectional approach. The sample was taken from the Statistics class population of School of Engineering, UOW Malaysia, Selangor Campus. There were 53 engineering undergraduate from a class were selected to participate in this study since they had already completed the statistics subject in the previous semester. Only 43 students completed the questionnaire, despite their willingness to cooperate. In order to collect information from the respondents, hard copies of questionnnaires were distributed to the students. and they were given period of a week to complete the survey questions. To minimize the occurrence of non-response errors, students were encouraged to answer all questions presented to them.

The main objective of the study was to investigate students' perceptions and attitudes towards the learning statistics course. The questionnaires comprise of 27 items and is structured into two sections, demographic characteristics, and perspectives on formal statistics courses. The first section (Section A) comprises of 6 items such as gender, highest level of education, nationality, year of degree programme currently they enrolled, degree program that the students are enrolled, and their prior knowledge in statistics examined the demographic background of the respondents. The second section (Section B) examined the analysis of the research questions. It focuses on the student's perception towards the lecturer role in teaching statistics and students' perception towards the statistics course it self. The study uses Likert Scale as for its survey questionnaire. Attitudes towards formal statistics courses were evaluated using a five-point scale. . A 5-point likert scale was implemented with 5 being "Excellent" to 1 being "Poor."

RESULTS

Demographic Profile of the Respondents

This section examined the characteristics of the respondents, which comprises gender, nationality, education level, current undergraduate engineering program, current degree year, and statistical knowledge.

Table 1 *Demographic data of the respondents (n = 43)*

Characteristics	Categories	Number (%)
Gender	Male	37 (86.0%)
	Female	6 (14.0%)
Nationality	Local	36(83.7%)
	International	7(16.3%)
Education Level	Matriculation/Foundation/A-level	26 (60.5%)
	Diploma	17(39.5%)
	Others	21 (48.8%)
Program	Degree in Electrical Engineering	9 (20.9%)
	Degree in Mechanical Engineering	18 (41.9%)
	Degree in Mechatronic Engineering	16 (37.2%)
Current Degree Year	Year 1	1 (2.3%)
	Year 2	24 (55.8%)
	Year 3	17 (39.5%)
	Year 4	1 (2.3%)
Statistics Background	Yes	38 (88.4%)
	No	5 (11.6%)

As the research aimed to find students' perceptions and attitudes towards statistics, the subsequent discussion focuses on the outcomes derived from the study. The first finding relates 13 questionnaires to the student's perception toward lecturer's role in teaching statistics. This finding is elaborated upon in the following discussion as can be seen in Figure 1.

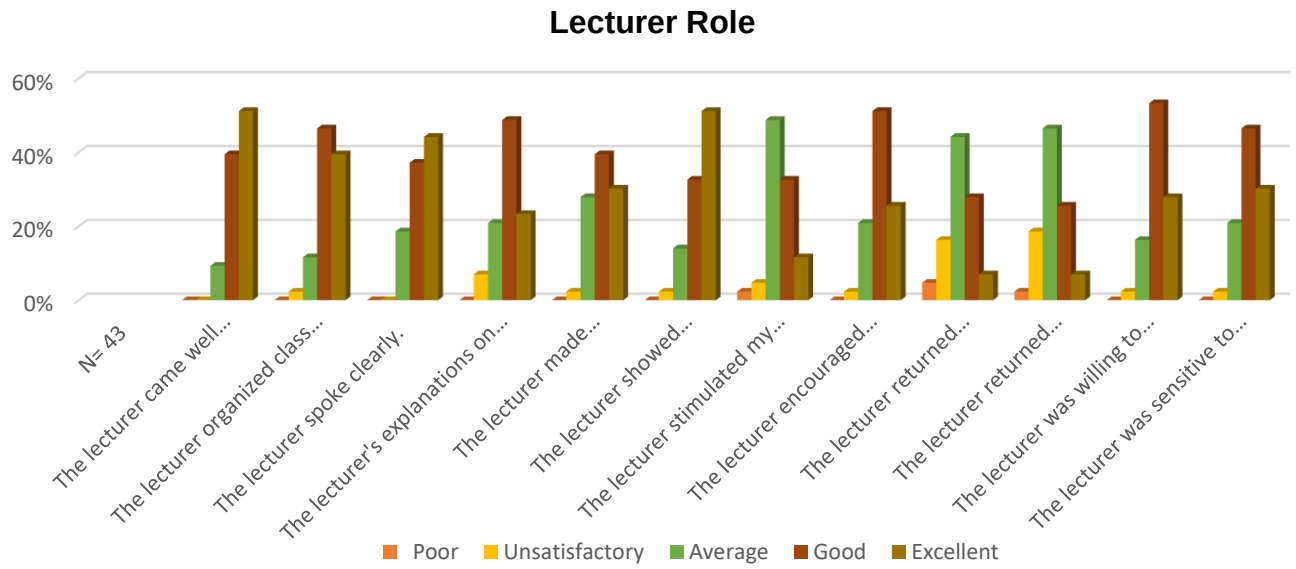

Figure 1: Student's perception toward lecturer's role in teaching statistics.

Based on Figure 1, majority of students approximately 90.7% students indicated excellent (51.2%) or good (39.5%) to the statement that lecturer came well prepared for class session. Effective learning will only takes place in a classroom when the lecturers' themselves show interest in teaching the subject and be well prepared to clear the doubt among the students. Moreover, about (86%) and (81.4%) of students rated good or excellent rating as a respond to the statements that their statistics lecturer organized statistics class sessions well, and lecturer spoke clearly. They (72.1%) also said that the lecturer's explanations on working steps were clear and this can be seen by their good or excellent rating given for the statement. The students also said that the lecturer made the assessment clear. This can be seen form the occurrence (69.7%) for good or excellent rating. Most of them (83.8%) feels that the lecturer showed enthusiasm in teaching statistics. However, partially (48.8%) of them agree with the statement the lecturer stimulated their interest in statistics. In addition, (76.8%) stated their lecturer encouraged student participation during the class discussion and group activities. The respondents feel that their lecturer supports their learning process through engaging them in group discussion and appropriate learning activities. Interaction with peers will help the learners to gain confidence in their learning. They (34.9%) feel that the lecturer returned student's work and assignments with useful feedback. It is also similar (32.6%) indicated the lecturer returned student's work and assignments in a timely manner. They (81.2%) students stated that the lecturer was willing to offer individual help and (76.7%) stated the lecturer was sensitive to and concerned about student progress in statistics.

The next findings in Figure 2 deal with students' attitude towards learning statistics. In this section students were asked about their perception toward Statistics.

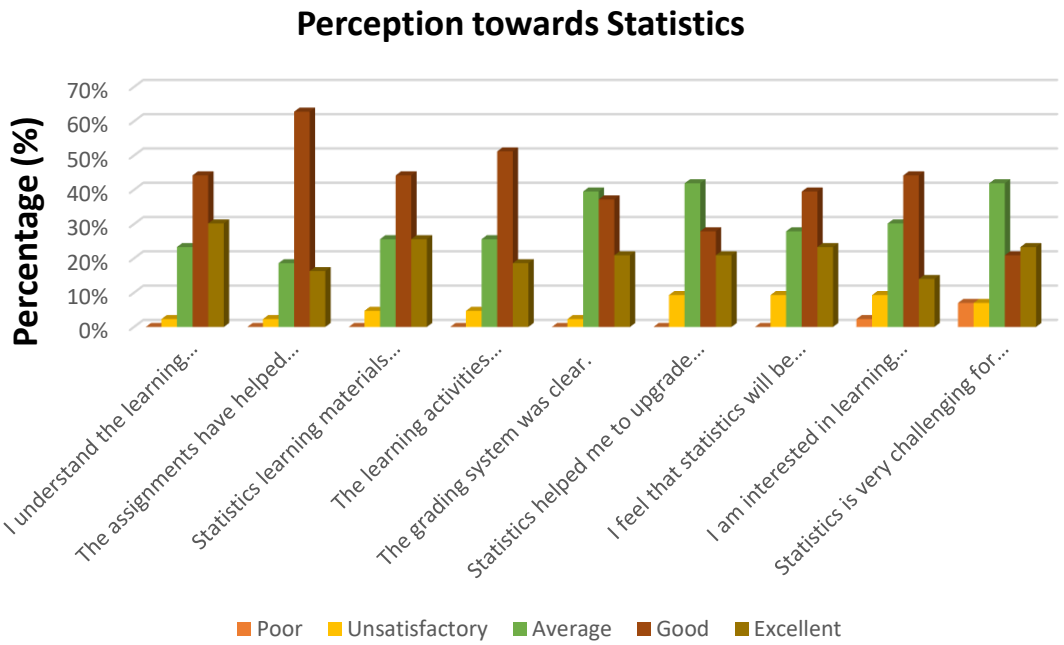

Figure 2: Student's perception towards learning statistics.

Most of the students have good perception toward statistics as they (79.1%) rated good or excellent for the statement assignments have helped them to understand statistics better. The second statement concerning if the learning outcomes were clearly stated in the syllabus. There were (69.8%) rated excellent or good for the statement that statistics learning materials provided by the lecturer contributed to their learning. However, there were (4.7%) do not agree with this statement. They were only (48.8%) stated that statistics helped them to upgrade their knowledge in engineering. However, they (68.2%) feel that statistics will be useful them in their profession. There were 58.2% feel that they interested in learning statistics and there were 44.2% stated that they find statistics is challenging for them.

Table 2: Correlation between prior knowledge in statistics and level of challenges of the subject

	N	Correlation	Sig.
Knowledge & Challenge	43	.043	.782

Table 2 shows the difference between the prior knowledge of students in statistics and if the students find that statistics is very challenging for them. It appears that there is very weak positive correlation (r = 0,043) between students' prior knowledge in statistics and their perception of the subject as challenging. However, it was found that there is no significance difference between students' prior knowledge in statistics and if they find statistics is challenging for them as indicated by p-value of 0.782, as it is much higher than the used significance level of 0.05.

DISCUSSION

The research highlights statements on the perceptions toward lecturer's role in teaching statistics, students' perception towards statistics, and correlation between prior knowledge in statistics and level of challenges of the subject. 90.7% said that the lecturer was well organized for the class session. Effective learning will only take place in a classroom when the lecturers' themselves show interest in teaching the subject and be well prepared to clear the doubt among the students as quoted by Kutluca, T. (2013) that teachers should organize appropriate materials, should provide collaborative activities, should prepare debate and problem-solving environment. They (72.1%) also said that the lecturer's explanations on working steps were clear, and this can be seen by their good or excellent rating given for the statement.

Our findings reveals that 44.2% find statistics subject challenging, this coincides with a similar study conducted by Male, et al (2021) that statistics can be perceived as a challenging subject, and some students may experience anxiety related to dealing with numbers and data analysis. Hence, it can cause slow learning and problem-solving abilities among the students.

Findings suggests that 68.2% feel that statistics will be useful to them in their profession. According to (Ado, 2013; Tack & Vanderlinde, 2014) the skills and abilities developed during research assignments are not only essential for completing their academic tasks, but also have a significant impact on their future careers as they engage in ongoing research in their career.

No significant differences were found in the comparison of findings on the student's prior knowledge and level of challenges of the subjects. Male. et al (2021) described that the students who are motivated to learn statistics are more likely to put in the effort and time required to understand the subject. On the other hand, a lack of motivation can result in a can hinders their learning progress. Overall, the research suggests a positive outlook towards statistics among students, with opportunities for targeted improvements to better meet their diverse needs and increase relevance to engineering field.

CONCLUSIONS

The research explored the student's perception toward lecturer's role in teaching statistics and student's perception towards learning statistics. In conclusion, the research highlights a generally positive perception among students towards both the statistics lecturer's role and the subject of statistics itself.

Further study with large sample size may give a concrete or better results to enhance the reliability and validity of the findings. Additionally, individual interviews or focus groups in future works will provide a deeper understanding of students' experiences and help identify areas for improvement in teaching statistics ultimately shaping the perspectives of future engineers.

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BREAKING BARRIERS TO FOSTER EQUITY AND INCLUSIVITY IN HIGHER EDUCATION: A CASE STUDY AT DEEPSTAMBH FOUNDATION, JALGAON, MAHARASHTRA, INDIA

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ABSTRACT

A higher level of education is linked to greater living standards and is essential for the maintenance of democratic societies. It also plays a major role in the economic development of countries. The issue of inclusivity and equity in access to higher education has gained prominence in government and international organisation education strategies. Higher education accessibility for people with physical limitations is a global issue. In view of the COVID-19 pandemic's exposure and amplification of inequality and exclusion from schooling, effective measures that promote fairness,equality and social inclusion are imperative. One of the main focuses of inclusive education research is information and resource access with visual disability receiving the greatest attention. Universal design is one tactic that seems to hold potential for promoting diversity in higher education. Despite an increase in the number of physically challenged college students, some of them are still unable to gain technical proficiency and a mainstream career. Under the project "Erasmus+ ERASMUS-EDU-2022-CBHE-STRAND-1 Project No. 101082909",cofunded by European union,project partner, "D.Y.Patil College of Engineering and Technology,Kolhapur", India, aims to examine various practices of inclusive and equitable education adopted by the, "Deepstambhfoundation,Jalgaon", India, as a case study. Furthermore, it will investigate the relationship between higher educationand SDGs 4 and 8,giving a guideline for development of a framework of HEIs and curriculum accordingly .

Keywords :Erasmus+; Deepstambh Foundation; Inclusive education; Equitable education;SDG;India.

INTRODUCTION

It is a global concern that those with physical limitations have access to higher education. Despite the poisonous correlation between poverty and disability, especially in the global South, the majority of the scholarship on disabilities in higher education has come from the global North. [1]. Given the exposure and aggravation of inequality and exclusion from schooling caused by the COVID-19 epidemic, effective policies promoting equality, fairness, and social inclusion are imperative [2]. [3]. One of the main areas of research in inclusive education is information and resource access, with visual disability being the subject of the most analysis [4]. [5]. Universal design is one approach that seems to hold promise for diversity in higher education. Although the proportion of physically challenged students in higher education has increased, some of them still remain deprived of technical competency and mainstream caree. Discussing with respect to the Indian scenario,for those with physical impairments, higher education in India comes with a number of challenges. These include a lack of options for public transportation, negative perceptions of individuals with disabilities, inadequate infrastructure, and a shortage of support services. [6] [7]. Despite the potential advantages of higher education, the current situation in India suggests that very few disabled individuals are able to pursue postsecondary education [8]. In India, efforts are being made to advance inclusion and equity in higher education [9]. India's new education strategy aims to provide comprehensive education from kindergarten to the highest level, with a focus on student diversity [10]. To increase equity and inclusion, learner motivation

needs to be generated and sustained through customized induction programs, faculty mentoring, and inclusive lecture delivery [9]. Technology utilization can also be advantageous for these activities. The COVID-19 pandemic has highlighted the need for addressing equity issues in higher education [10]. The capacity approach may be used to create strategies that consider the requirements of pupils who are marginalized, disabled, and from socioeconomically and socially disadvantaged backgrounds. At the moment, the capacity approach needs to incorporate inclusivity and equity in higher education for individuals with impairments.

MATERIALS

BENEFITS OF EQUITABLE AND INCLUSIVE HIGHER EDUCATION

It provides equal opportunities for all students to succeed academically, regardless of their circumstances [9] thus promoting justice and reduces educational inequities. It improves bonds between students and promotes a sense of community.Students who think the school climate is pleasant tend to do better academically and are happier with their college experience [9]. Diversity, Equity, and Inclusion (DEI) policies can help higher education institutions better serve diverse communities and advance social justice [10]. It enables the development of a culture that cares about and supports faculty and staff of color, fostering more equitable hiring practices and talent retention.

BARRIERS/ CHALLENGES TO EQUITABLE AND INCLUSIVE HIGHER EDUCATION

One of the main obstacles to fair and inclusive higher education is the underrepresentation and lack of visibility of women in positions of authority within the institutions, which prevents them from advancing in their careers and prevents them from being included [18]. Students are also deterred from pursuing higher education by financial hardship and a lack of skills needed to construct effective scholarship applications [10]. A lack of inclusion and belonging among marginalized identity groups in higher education institutions is also a result of social exclusion, accessibility issues and incidents of bias and discrimination .Measuring and monitoring the advancement of inclusion and social justice in higher education is also difficult due to the requirement for credible and workable policy indicators as well as contextualized notions of justice and equality.

METHODOLOGY

The research design is descriptive qualitative, utilising a case study method to investigate the current implementation of inclusive and equitable practices in education at the Deepstambh Foundation in Jalgaon, Maharashtra, India. It also investigates the relationship between sustainable development goals (SDGs) 4 and 8 in higher education. A literature review was conducted to identify parameters for the setting up of methods. The primary data was gathered via a live case study visit to the Deepstambh Foundation and conversations with stakeholders. The secondary data was obtained through a literature review. Recognising student diversity involves acknowledging and valuing the diverse cultural, linguisticand socio-economic backgrounds that students bring to the classroom. Sustainable Development Goal 4 and 8 aim towards inclusivity and equity for physically challenged students by opening avenues of quality education by providing them personal autonomy and employment. Here SDG 4 ensures comprehensive and equitable quality education and encourages lifelong learning opportunities for all. It also includes equitable achievement in higher education, suitable skills for good work, gender equality&inclusion and universal youth literacy.SDG 8 encourages long-term, inclusive, equitable and sustainable economic growth, full and productive employment, and decent work for everyone. The paper elaborates the strategies of inclusive and equitable education and practices adopted by Deepstambh Foundation finally relating them to SDGs.

THE CONCEPT OF EQUITABLE AND INCLUSIVE EDUCATION

By implementing Different practices, educators can create inclusive learning environments that meet the needs of all students, promote collaboration and support, and ultimately, enhance educational outcomes for everyone involved. These different practies are like: Differentiated Instruction(DI),Universal design for

learning (UDL), Teaching with Cultural Sensitivity, Collaborative and Cooperative Learning, Flexibility in Assessment, Accessibility of Learning Content, Inclusive Language and Communication, Community Engagement.

Table 1: The idea of inclusive learning

Sr. no	Strategies	Application at Deepstambh Foundation	SDG mapped
1.	*Differentiated Instruction*	I.Computer Lab: well-equipped, assistive technology ,kibo device for visually impaired SDG 4 II.Library& Reading room- adequate library, braille books, audiobooks, ebooks, and two reading rooms with inclusive furniture.SDG 4 III.Skill& hobby centre– products using various techniques for skills like painting, clay modelling,handicrafting etc, displayed in exhibition for sale.	SDG 4 SDG 4 SDG 8
2.	Universal design for learning *(UDL)*	I.Infrastructure - universal design principles II.Computer Lab – well-equipped, assistive technology, kibo device for visually impaired. III. Foundation prepares students for mainstream career with placements for the students.	SDG 4 SDG 4 SDG 8
3.	*Teaching with Cultural Sensitivity*	I.Learning through group discussions by students with cultural and economic diversity promoting a culture of student collaboration to learn and share. II. students are grouped into A, B & C categories of students. A – Advanced, B – Average, C – Slow. A promoted & trained for MPSC, UPSC exams, B given personal touch, while training & if found progressive are promoted to type A. C diverted to skill based courses and training	SDG 4 SDG 4
4.	*Collaborative and Cooperative Learning*	I. Learning through group discussions by students with cultural and economic diversity promoting a culture of student collaboration to learn and share.	SDG 4
5.	*Flexibility in Assessment*	I.Tests to monitor students' academic progress and implement corrective measures. II.During the course of teaching, students are divided into three categories: A, B, and C.where, A represents Advanced learners, B -represents Average learners, and C represents Slow learners.	SDG 4 SDG 4
6.	*Accessibility of Learning Content*	I.Braile and Abhyasmitra app, access curated and recorded expert lectures . II.Deepstambh possesses technology advancements required to offer online education	SDG 4 SDG 4
7.	*Inclusive Language and Communication*	I. Computer Lab : well-equipped , assistive technology ,kibo device for blind.II.Library& Reading room- adequate library , braille books, audiobooks, ebooks, and two reading rooms with inclusive furniture.	SDG 4 SDG 4
8.	*Community Engagement*	I.At Deepstambh -number of NGOs volunteer, reading initiatives in schools and colleges,establishes rural libraries,expert talks and workshops to raise awareness among parents, teachers and students.	SDG 4

EQUITABLE LEARNING

By implementing Different practices, educators can create inclusive learning environments that meet the needs of all students, promote collaboration and support, and ultimately, enhance educational outcomes for everyone involved.These different practies are like: Differentiated Instruction(DI),Universal design for learning(UDL), Teaching with Cultural Sensitivity, Collaborative and Cooperative Learning, Flexibility in Assessment, Accessibility of Learning Content, Inclusive Language and Communication, Community Engagement.the various stratergies adapted at Deepstambh Foundations are mentioned in following table

Table 2: The idea of Equitable learning

	Strategies	Application at Deepstambh Foundation	SDG mapped
1.	Engaging students, families and communities as full partners	Communities advisory board, Families- personal meet,feedback, Supportive alumni ,feedback.	SDG 4
2.	Diversifying the educator workforce	Advisory board,experts,teachers,alumni,families participating in formulation of policies,curriculum at par with the students varied needs.	SDG 4
3.	Providing meaningful professionaldevelopment and supports	TTP – educational values, dos , donts, ethics etc. Mentoring, personal touch must, Non-residential training for extra remote area.	SDG 4
4.	Ensuring equitable access to rigorous Culturally sustaining curriculum	Equity and inclusivity of students all over the nation, Support to students from remote areas, Academic and personal counselling of every student.	SDG 4
5.	Provide access to integrated services and supports	Non residential training with food, Counselling, financial assistance,gadgets provision, Every room donated,doctors,healthy food and diet food for specific needs.	SDG 4
6.	Adopting Various Forms of Assessment Strategies	Tests, academic progress,learning outcomes, Grouppresentations,debates,Slow,average,advanced learners identification.	SDG 4

OBSERVATIONS

Totally inclusive infrastructure, Non-government funded Equips students for mainstream career and skill based career, Cohesive and symbiotic environment, Fresh food, diet food for fostering physical and mental health of students, Accessible to remote areas, Alumni support, Transparency in every work, Personal autonomy, Effective digital advancements, Passionate and innovative teachers, Discipline, Overall it is observed that the teaching learning process follows a continuous “plan do check act “cycle which results in constant improvement and development of students. Biometric of student all data field unique prn number generated, Extra care and facilities are provided for students of extra remote areas by providing them with mobiles and recharge,Non residential training for 50 students from remote areas is conducted every year this training is enhanced by food facility counselling facilities, Test are conducted frequently to track the academic progress of students and take corrective measures accordingly.

LEARNINGS

A strong social networking needs to be developed for raising funds for the project and to run the project,Quality of students is a must all efforts should be taken collectively for his or her overall development,Alumni support necessary as a marketing strategy,Work transparency to be maintained, Cultural diversity should be overcome,Accessibility to remote areas should be efficiently done and they should be facilitated with technology help if needed,A well developed digital platform is important equally important is a competent faculty,Strong support from every stake holder needed ,hence they should be involved at all levels,Personal autonomy,Orientation for sensitization of inclusivity in education needs to be done in remote areas,Limitations of online exams. (A. Electricity B. Range C. proctoring of exams) A and B can be overcome by increasing efficiency in network and some local policies for electricity C. can be mitigated by developing and you using efficient software for conduction of exams.

CONCLUSION

By making a few appropriate modifications, this study outlines the future possibilities for the equitable and inclusive framework of curriculum design for all spectrums. This indeed would contribute to the noble intention of ERASMUS project, "Erasmus+ ERASMUS-EDU-2022-CBHE-STRAND-1 Project No. 101082909."

ACKNOWLEDGEDMENTS

The research reported in this paper is based on the visit conducted under the Project "Erasmus+ ERASMUS-EDU-2022-CBHE-STRAND-1 Project No. 101082909 - Fostering Inclusive and Equitable Quality Education to stimulate lifelong Sustainable Learning opportunities for HEIs in India.The project is funded by the EUROPEAN UNION.The visit was conducted by faculty of D.Y.Patil college of engineering and technology ,Kolhapur,India. The research analysis presented in the paper is solely the responsibility of the authors and does not necessarily represent the official views of the Institute . The authors gratefully acknowledge the help extended by officials at DEEPSTAMBH FOUNDATION, JALGAON, INDIA. Additionally,they are thankful to SARVAJANIK EDUCATION SOCIETY, Surat, Gujrat, Coordinator of the project"Erasmus+ ERASMUS-EDU-2022-CBHE-STRAND-1, for giving them the opportunity to work on this project.They also appreciate that D.Y.Patil college of engineering and technology ,Kolhapur,India, allowed them to use its facilities and services for the research.They give credit to the digital assistance offered by resources such as scispace and paraphrasing tool Quilt Bolt.

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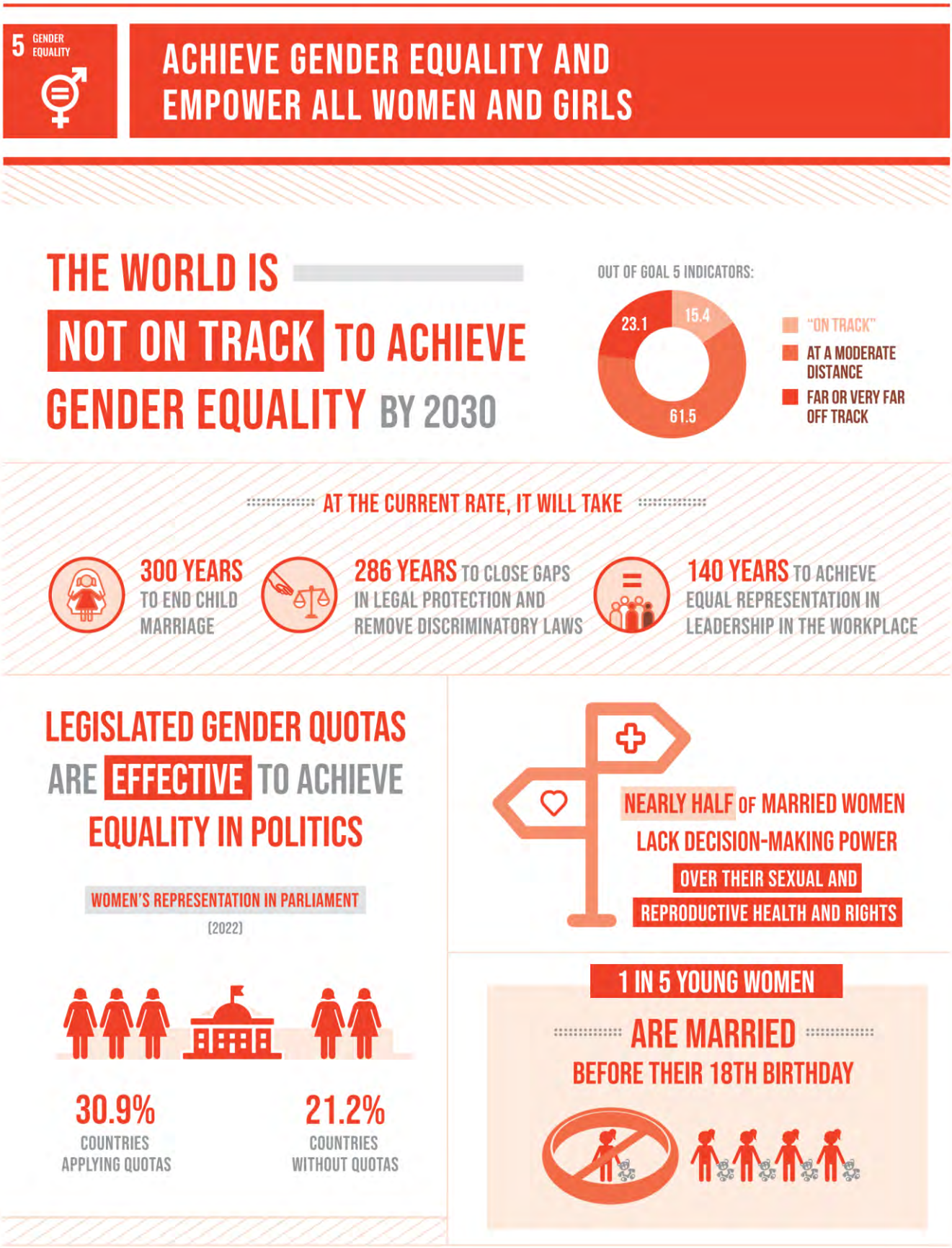
GOAL 5: ACHIEVE GENDER EQUALITY AND EMPOWER ALL WOMEN AND GIRLS



Source: UN's The Sustainable Development Goals Report 2023 – Special Edition

DISTRIBUTION AND RENEWAL OF PRODUCTIVITY SCHOLARSHIPS BY SEX IN ENGINEERING RESEARCH IN BRAZIL

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ABSTRACT

One form of recognition and incentive in academia is the awarding of productivity grants. In Brazil, the most prestigious research scholarship is the “PQ grant” or “PQ scholarship” provided by the National Council for Scientific and Technological Development (CNPq). Many authors have noticed that women are underrepresented among PQ grant holders, but an analysis focusing solely on the Engineering field was not found in the literature. In this context, this study aimed to analyze the distribution and renewal of PQ grants by sex in the field of Engineering in Brazil. For the analysis, we obtained the list of PQ grant recipients from the CNPq website and determined the researchers' sex using the GenderAPI and ChatGPT tools. The results showed that the proportion of female PQ grant recipients decreases as the rank of the grant increases and that women are more likely to lose the grant than men. In the analyses conducted, 50-70% of women renewed the grant, while the rate for men was 71-82%. These findings confirm the presence of the Leaky Pipeline in the distribution of PQ grants in Brazil, emphasizing the need for policies to promote gender equality.

Keywords: PQ Grant; Gender gap; Engineering; Scissor Effect; Leaky Pipeline.

INTRODUCTION

The National Council for Scientific and Technological Development (CNPq) is a Brazilian agency whose mission is to promote science, technology, and innovation in the country [1]. CNPq is one of the main funding bodies in Brazil, awarding grants for projects and researchers at all levels. One of the most prestigious grants awarded by CNPq is the Productivity Scholarship in Research, a.k.a., the “PQ grant” or “PQ scholarship” [1].

The PQ grant was launched in the 1970s and since then has been consolidating and gaining value in the academic community [2, 3]. This grant is aimed at “researchers who stand out among their peers, valuing their scientific production according to normative criteria" [4]. In 2022, PQ grants were divided into 3 categories: Researcher 2 (or E), Researcher 1 (D, C, B, and A), and the Senior Research Productivity Scholarship (PQ-Sr). Thus, in terms of academic recognition, the scholarships rank in the following order: 2(E), 1D, 1C, 1B, 1A, and Sr (the most prestigious and rare).

Most academics who pursue research careers in Brazil apply for this grant, which lasts for 3 to 5 years. After that period, one must apply again and will be ranked according to their project and research metrics (publications, awards, and concluded supervisions in the last 5/10 years) about the other applicants.

Researchers who receive PQ grants have several benefits, including a monthly stipend paid by CNPq, advantages in funding calls, and priority in receiving certain scholarships for students [3]. Furthermore, PQ grants also represent prestige and influence in the scientific community [3], leading to more invitations for collaborations and participation in scientific groups.

A recent study on the distribution of PQ grants in Brazil showed that, in 2022, 65% of PQ grant recipients were men, and 35% were women. However, at level 1A, the highest level, 73% were men and 27% were women [5]. Additionally, the study showed that CNPq invested twice as much in PQ grants for men as it did for women [5]. No analysis focused on engineering was found. In this context, the objective of the present

study is to analyze, quantitatively and qualitatively, the distribution and renewal of PQ scholarships by sex[2] in the field of Engineering in Brazil. This work thus contributes to UN's SGD 5: Achieve gender equality and empower all women and girls.

MATERIALS AND METHODS

Initially, we obtained the list of PQ grant approvals from the 13 engineering courses/disciplines (as divided by CNPq): Civil, Sanitary, Transportation, Mining, Materials and Metallurgical, Chemical, Nuclear, Mechanical, Production, Naval and Ocean, Aerospace, Electrical, and Biomedical. This list was obtained from the final results of the selection processes for the grant, from 2018 to 2022 [6]. These files only included the researcher's name, institution, and the level of the scholarship. To determine the field of study of each scholar (and find those in the engineering area), we cross-referenced the names with the list of professors available on the Sucupira Platform [7], which provides information on the Brazilian Postgraduate System.

As there was no information about the gender of the PQ grant holders, we estimated their sex by their first names. To this purpose, we used the GenderAPI and ChatGPT to classify the names as "male" or "female". This classification was carried out using software to avoid unconscious bias. In GenderAPI, it's possible to provide geographic information about the query, which enhances the accuracy of the results. In total, 840 names were classified, from 3187 researchers. Names that were considered "unisex" by both tools (0.5%) were disregarded from our analyses. It is important to note that the gender classification of researchers constitutes a limitation of the study, as it relies solely on their first names, without considering individual gender identity or non-binary individuals. However, this strategy is commonly employed in similar studies that deal with large amounts of unlabeled data [8] [9].

RESULTS

Figure 1 shows the proportion of distribution of PQ grants according to the category/level of the grant and the sex of the researcher, since 2018. The graph shows that the proportion of female PQ grant holders decreases as the rank of the grant increases. Female participation starts from 22-24% on average (already a low number, given that around 38% of engineering PhDs in Brazil are women [10]), reaching only 5% in senior positions. This result is a clear representation of the Scissors Effect (since the enlarging gap resembles an opening scissor) - when women are underrepresented at higher levels of an organization or professional field. One can notice that the gap gradually reduces from 2018 to 2022, but not significantly.

The causes of this result may be related to [9]: (I) the effect of cumulative advantage, which refers to the tendency for individuals who are already successful to receive more resources and opportunities, which helps them become even more successful; (II) the effect of double or triple burden of female researchers, where women are primarily responsible for household chores and childcare, in addition to paid employment; (III) affinity bias, where there is a preference for individuals who are more similar to oneself in terms of ideology, attitudes, appearance, religion, among others; thus, in a predominantly male environment, men tend to be better judged and heard; (IV) networking and funding opportunities; and (V) lack of public policies and funding calls based 100% on meritocracy [11].

[2] Note: This work follows the best practices regarding the bias-free language of the American Psychological Association (APA Style). Thus, the term "sex" was adopted to refer to the biological sex assigned at birth (the one assessed in this study), instead of "gender," which is recommended when referring to people's social identity. Due to methodological limitations, we adopted a binary division of female/male (adjectives) or women/men (nouns).

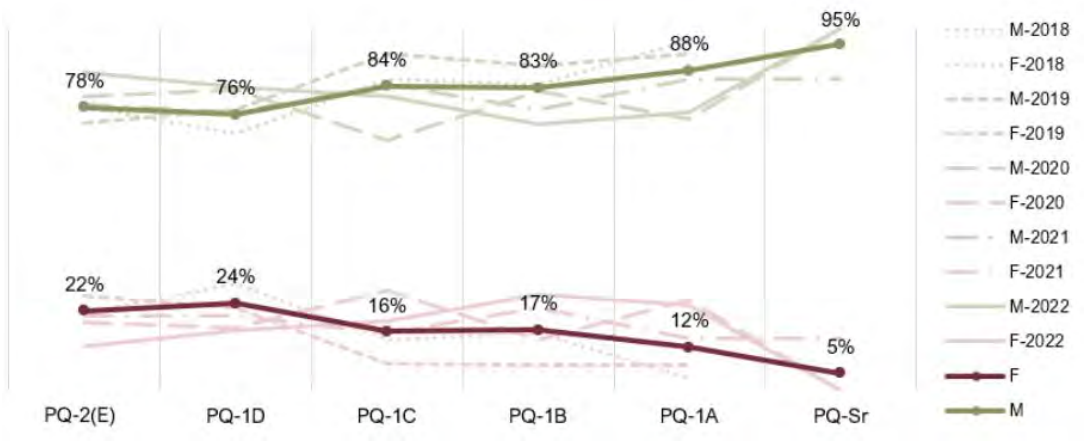

Figure 1 - Proportion of PQ grant distribution (from the approval results) in Engineering courses, according to researcher sex and grant level, from 2018 to 2022. "F" stands for female names and "M" for male ones. The stronger lines represent the average values for all years. Note: in 2018 and 2019, there were no calls for senior positions (PQ-Sr)

Figure 2 presents the percentage of PQ grant renewal, covering the researchers who remained as grant holders in the analyzed years (either progressing, regressing, or maintaining their category). This analysis was done by checking if the names of grant holders were repeated in any of the approval sheets posted after the end of their grant, up until 2022. Since the results of the selection processes were only available from 2018 onwards, we could not conduct this analysis for categories 1A and Sr, as both have a duration of 5 years. Grants 1B, 1C, and 1D last for 4 years (we could analyze 1 selection process), and 2(E) lasts for 3 years (thus 2 processes could be assessed).

Figure 2 shows that 71 to 82% of male grant holders were also approved in subsequent selection processes, while the percentage of female reapproval ranged from 50% to 70%. In other words, women lose the PQ grant more frequently than men, confirming the leaky pipeline. Furthermore, women in higher categories (PQ-1D, PQ-1C, and PQ-1B) have an even lower chance of renewing the scholarship than those in the lower category (PQ-2(E)), further confirming the scissors effect. Several of the previously mentioned factors may be also causing this behavior. We clarified that the non-renewal of the grant does not necessarily mean rejection of the renewal request. Researchers may have chosen, for personal or professional reasons, not to apply.

The consequences of this outcome go far beyond the financial loss for the researchers. Along with the PQ grant, they lose the opportunities derived from it and contribute to a lesser female representation in prestigious positions, placing them at a disadvantage within the meritocratic academia.

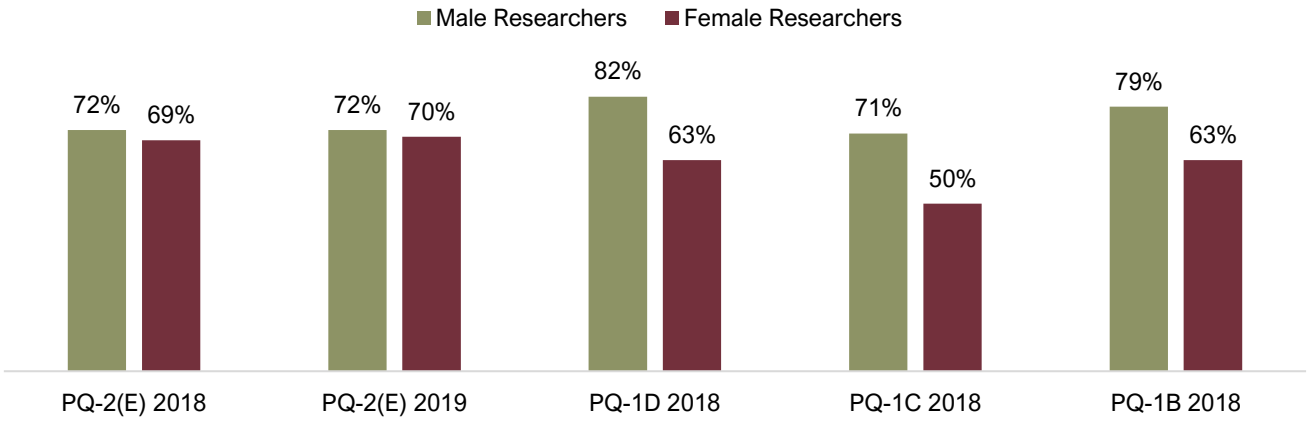

Figure 2 – Renewal rate of PQ grants according to the researcher's sex.

CONCLUSIONS

The distribution of PQ grants revealed a decrease in the proportion of women as the level of the grant increased, indicating the Scissor Effect. This gap is closing slightly over the years, but very slowly. Causes include the cumulative advantage effect, the effect of double/triple burden, affinity bias, networking/financing opportunities, and lack of inclusive policies. The analysis of the renewal of grants showed that women are more likely to lose the grant than men, confirming the Leaky Pipeline and the Scissor Effect. This outcome diminishes female representation in prestigious positions, disadvantaging them in meritocratic academia. These findings highlight the urgency of addressing related structural challenges in academia. In this scenario, it is necessary to rethink practices and policies to promote true equality of opportunities and recognition.

ACKNOWLEDGMENTS

The research reported in this paper was supported by CAPES under Grant 88881.744259/2022-01; CNPq (PQ grant for Julia Mendes), PROPP/UFJF, and PROPPI/UFOP. We would like to express our gratitude for their financial support, which made this work possible. The authors used ChatGPT to assist in translation and grammar checks. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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CAN WOMEN ORGANIC FOOD PRODUCERS IMPACT SUSTAINABILITY? A CASE STUDY IN BRAZIL

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ABSTRACT

In recent years, the growing interest in sustainable agricultural practices and a conscious lifestyle in relation to food consumption has highlighted organic food fairs as crucial places for promoting sustainable agriculture and women's personal development. In this context, this study aims to analyze how the work of women organic food producers can impact the development sustainability. To this end, a case study methodology was used in which three women were interviewed who add value to organic food by transforming it into new foods. As well as being a way of promoting sustainability by avoiding food waste, this economic activity has a direct impact on family income and the empowerment of these women. In addition, this study was able to point to fairs as a potential place for entrepreneurial development and empowerment for these women.

Keywords: Women, Waste-to-Value; Empowerment; Entrepreneurship; Organic food.

INTRODUCTION

In recent years, there has been a significant increase in interest in sustainable agricultural practices and a shift towards a more conscious lifestyle in relation to food consumption [1], [2]. In this context, organic food fairs have emerged as key places for promoting sustainable agriculture and providing access to high-quality, ecologically sustainable products [3]. However, as well as providing a viable alternative to conventional markets, these fairs also offer a potential environment for women's personal and professional development, contributing to the advancement of gender equality [4]. Thus, this study focuses on analyzing the active participation of women in organic food fairs, highlighting their significant contribution to the promotion of the Triple Botton Line (TBL), since it aims to analyze not only the economic aspects, but also the environmental and social ones [5].

Using a case study approach [6], the context of the city of Itajubá, Minas Gerais, Brazil, was closely investigated, where women play an essential role in transforming fresh food into higher value-added products such as cakes, breads and cookies. This work practice is directly aligned with the concept of Waste-To-Value (WTV), which refers to the act of transforming products that would otherwise be discarded, waste and by-products into new products with greater added value.

In this way, this study seeks to answer the following research question: How can the work of women organic food producers impact sustainability? In addition, the aim is to understand what role these women play in reducing food waste and promoting environmental and social sustainability in their communities.

MATERIALS AND METHODS

This study adopted a qualitative approach, using case study methodology [6] to investigate women's participation in organic food fairs and their impact on sustainability. The participants are women active in the Feira Agroecológica e Cultural de Itajubá (Itajubá Agroecological and Cultural Fair) (FACI), a public-private initiative in the city of Itajubá, MG, Brazil. The sample is made up of women aged between 35 and 45, with different educational and working backgrounds, to capture a variety of perspectives and experiences. Data was collected through semi-structured interviews, conducted face-to-face at the weekly market, with the audio recorded to ensure the fidelity of the information.

RESULTS

PROFILE OF THE WOMEN INTERVIEWED

Among the six stalls registered as home-grown for the fair [8], the research found only three (03) women who sell products that contain ingredients from local organic production with the potential to contribute to WTV and CE. General information about the interviews can be seen in Table 1 below.

Table 1 – Characterization of the participants

Identification (age)	Education	Marital status	Children	Contribution to family income	Products sold	Organic food WTV	Length of service
X (43)	Primary Education	Married	1	50%	Cakes, cookies, cream cookies.	Carrot, orange, eggs and milk.	20 years
Y (45)	Primary Education	Married	2	50%	Wholemeal cakes	Apple, banana, carrot, milk and eggs.	20 years
Z (38)	Graduation	Married	3	33%[3]	Tomato confit, preserves, jams, jellies and breads.	Tomatoes, seasonal fruit, milk and eggs	5 years

ENVIRONMENTAL SUSTAINABILITY

Regarding issues involving environmental sustainability such as reusing waste, using by-products and reducing waste, the answers were quite divergent. All the interviewees stressed that organic agricultural production is essential for keeping the environment, but not all the ingredients used in their recipes come from organic sources. Despite finding their customers' interest in and need for organic products with local ingredients and the great demand for products for diets with dietary restrictions, most of the interviewees offer few options that meet this demand in their catalogs.

The interviewees mentioned sustainable farm management several times, with initiatives to care for the soil and manage crops in such a way as to guarantee the preservation and health of local ecosystems. It is important to emphasize that the interviewees are part of family farming groups, in which all family members take part in organic food production. Interviewees X (43) and Y (45) do not work with seasonal products, which means that there are periods of the year when the availability of inputs is lower, which directly interferes with the fixed catalog, and they try to make up for this shortfall by buying products from other organic producers. They also report that they prefer to use food that would not have as much chance of being sold at fairs because of its appearance, thus avoiding losing it. However, they showed concern and resistance to admitting that they used these products, considering that consumers often don't understand that the nutritional quality of food is independent of its appearance. All the interviewees reported making recipes in which they could use all the parts of the food, including those that would normally be discarded, such as the peels. Interviewees X (43) and Y (45) sell their products in plastic packaging, while Z (38) chooses to distribute them in a more sustainable way, with baskets and glass packaging, which are returned and sanitized for distribution again.

[3] The products produced by the interviewee together with her husband account for 100% of the family's income, but products produced by her alone do not count towards this contribution.

ECONOMIC SUSTAINABILITY

Interviewees X (43) and Y (45) said that they had been producing food from organic ingredients for a long time and that they had a physical store before they went to the fair. For them, the fair provided an enterprise that needed less time, greater sales, and a better quality of life, which made them decide to dedicate themselves solely to the fair. For Z (38), her family's transition to organic food production came about as a response to economic and personal changes, including the need to find an alternative source of income after her husband's unemployment. All the interviewees reported that they actively contribute to the family income, and that they are viewed with respect by their husbands since they can contribute to expenses as equals.

One of the challenges faced by the interviewees is the difficulty in pricing their products, which, because they are of organic origin, could have a higher final value. However, even though the market is in one of the city's noblest neighborhoods, they notice that some customers complain when there is a small price adjustment, and this directly interferes with sales. In view of this, they choose to keep a profit margin that is sufficient to keep the products and contribute to the family income. Looking at the prices of the products on offer in comparison to local markets, they are below par.

The interviewees took part in training courses offered by the municipal government and a federal rural technical assistance agency, which covered both the production of organic food and the development of recipes using organic inputs produced by family farming. None of the interviewees has any training in administrative or business areas, but it was possible to see that they are innately entrepreneurial. The interviewees receive help from family and friends to learn how to control inputs, expenses, profits, and tax issues. The need for greater knowledge for their enterprise was presented as a challenge by the interviewees, the need for acquired entrepreneurship [9].

SOCIAL SUSTAINABILITY - WOMEN'S EMPOWERMENT

One point that stands out in all the interviews is the involvement of the family in all stages of production: not only do the wives and husbands work together as a team, but the children also take part. Even those who are of school age and do not actively take part in the fair are involved in the processes of planting, sorting and packaging the products. The mothers also point out that, by experiencing the family's economic development, the children also feel encouraged to develop activities to earn their own income and satisfy their personal financial needs.

Z (38) shared her experience of entrepreneurship, proving how her journey in organic farming has contributed to a greater sense of autonomy and personal fulfillment, especially compared to her previous job in the health sector. She mentioned the importance of support from the local community and the exchange of knowledge between rural producers, highlighting how these social networks play a fundamental role in strengthening family farming and promoting female empowerment in the countryside. All the interviews highlighted the equality of speaking space in the community in which they live. The interviewees reported that, unlike in other spaces, they felt listened to and respected when expressing their opinions, which reinforces the empowerment potential of these spaces.

All the interviewees shared that entrepreneurship in food production using organic inputs strengthens their role as provider and manager of the agricultural business. They also pointed out the importance of mutual support between family members and the appreciation of women's work in the countryside, showing how women's active participation in agriculture contributes to the economic and social development of rural communities. None of the women interviewed reported having suffered any kind of gender discrimination, which may reinforce the indication that these spaces, the fairs, and food production can be promising for women's development and for the promotion of Sustainable Development Goal 5 (SDG-5), which seeks ways to achieve gender equality and empower all women and girls.

CONCLUSIONS

In conclusion, this study highlights the essential role of women in organic food fairs, not only as producers and traders, but also as agents of change towards sustainability. By analyzing their active participation in these fairs, one can see not only the tangible economic benefits for their families and communities, but also the positive impacts on promoting sustainable agriculture, reducing food waste, and strengthening female empowerment. Bearing in mind that the training incentives made possible by public authorities have already shown positive results in both economic and social aspects in the lives of producers, it is important that these points are considered when proposing public incentive policies to expand the positive results and contribute to improving sustainable practices. Finally, organic food fairs appear as favorable spaces for women's personal and professional development, offering opportunities for growth and contributing to a broader understanding of the role of sustainable agricultural practices in promoting a more fair and resilient society.

ACKNOWLEDGEDMENTS

The authors would like to thank CNPq, FAPEMIG and CAPES for their financial support for the projects that supported this work's development.

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SCISSOR EFFECT IN WOMEN'S ACADEMIC CAREERS WITHIN BRAZILIAN ENGINEERING POSTGRADUATE PROGRAMS.

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ABSTRACT

The academic field is known for its cumulative nature, where early differences in one's career can have substantial effects in their future. The percentage of women in STEM disproportionately decreases as the career progresses [1]. This phenomenon, known as the scissor effect, will be the focus of this study. Using data from scientific and higher-education agencies (CNPq and CAPES) for all engineering courses, we observed a remarkable gender disparity in academic careers in Brazil. The analysis revealed a progressive decline in female representation, starting at 37% on master's degree and decreasing to only 8% at the senior research level. The most evident "leak" of women is observed from the PhD level (38%) to professor level (24%). The scissor effect is noted among both students and faculty over a decade (from 2013 to 2022), emphasizing the urgent need for reforms in Brazilian postgraduate programs to promote gender equity in academia.

Keywords: Scissor Effect; Gender Disparities; Engineering; Academic Career Gender Gap; Women in STEM.

INTRODUCTION

Historically, women's work was limited to domestic roles, leading to their distance from scientific and technological careers [2]. Women's access to education began in the mid-17th century, gradually altering their representation in society [3]. However, to this day, gender inequality remains a persistent challenge in academia, with biases and systemic effects adversely affecting the careers of individuals who identify as women worldwide. This issue is particularly pronounced in Science, Technology, Engineering, and Mathematics (STEM) fields, historically dominated by men [1].

The first engineering course in Brazil was established in 1792 in Rio de Janeiro [4], but the first female engineer in Brazil graduated only 153 years later, in 1945, from the Federal University of Paraná. The first woman to teach in an engineering course in Brazil began her career in 1947 at the Federal University of Rio de Janeiro [5]. In 2020, female professors were only 28% of members of graduate programs in Civil Engineering in Brazil [6]. The under-representation of women in faculty positions may perpetuate itself through the lack of role models for female students [6]. The same is valid for senior research and leadership positions, which will reflect in institutional support, networking, and collaboration for women [7].

The representation of women in engineering teaching and research roles is a multifaceted issue that deserves closer examination. In this study, we delve into gender disparities within engineering academic careers, shedding light on the scissor effect. With this goal, we seek to disclose data on female participation in engineering education in Brazil, while addressing gender-related challenges, barriers to career advancement, and biases in women's academic journeys. By promoting greater gender equity in academia and contributing to the academic success of women researchers, this study contributes to UN's SGD 5: Achieve gender equality and empower all women and girls.

MATERIALS AND METHODS

The research began by obtaining a list of beneficiaries of productivity grants from the Brazilian National Council for Scientific and Technological Development (CNPq), known as PQ grant holders. The PQ grant is a highly esteemed title awarded to the top researchers in each knowledge area. In addition to a monthly stipend, this grant brings various indirect advantages, such as collaboration opportunities and priority in other funding calls. The PQ grant varies from PQ-E (lower rank, around ~1200 grants available for engineering courses combined) to PQ-Senior (highest rank, around 40 grants available for engineering courses combined).

Most academics who pursue research careers in Brazil apply for this grant, which lasts for 3 years. After that period, one must apply again, and will be ranked according to their project and research metrics (publications, awards and concluded supervisions in the last 5/10 years) in relation to the other applicants.

We acquired the lists of PQ grant holders from the CNPq website, for all the 13 engineering courses, in August 2022. The present work evaluated all courses combined. There are 2 lists: ongoing grants categorized by knowledge area [8] and the final results of the selection processes for productivity grants [9]. We used the first list to analyze the distribution of ongoing grants by gender, and the second to investigate the renewal of grants by gender.

Subsequently, a search was conducted on the Coordination for the Improvement of Higher Education Personnel (CAPES) [10] to obtain the numbers of faculty and students from engineering Brazilian postgraduate programs, also by gender. The platform lists the names of students who got a master's or PhD title each year, their advisors, and institution.

The absence of gender information in both platforms required a gender classification process, which was done based on the academics' first names. To this purpose, we used the GenderAPI application and the artificial intelligence tool ChatGPT, to avoid unconscious biases. In total, 835 names were classified, from 2066 researchers. Names that were considered "unisex" by both tools (0.5%) were disregarded from our analyses. It is important to note that gender classification of researchers constitutes a limitation of the study, as it relies solely on their first names, without considering individual gender identity or non-binary individuals. However, this strategy is commonly employed in similar studies that deal with large amounts of unlabeled data [11] [6].

RESULTS

Figure 1 illustrates the gendered proportion of master's and doctoral students, faculty in Brazilian postgraduate programs (PPGs), and PQ researchers in engineering disciplines, by rank (effective in 2022). The discrepancy becomes evident at the master's level, with only 37% female representation. Progressing to higher levels, the gap widens to only 8% women and 92% men at the PQ-senior level. The enlarging gap resembles an opening scissor, thus evidencing the scissor effect throughout the engineering academic career in Brazil. As the prestige level increases, female representation decreases.

Several factors contribute to this gender gap, including biases in representation, cumulative advantage, double or triple burdens, lack of institutional support, lack of representation, citation gaps among others, which leads to the leaky pipeline. The leaky pipeline [12] illustrates the "drainage" of women throughout their careers, focusing on pivotal moments of decision-making and transition. The most important "leaking" stage in Figure 1 appears to be the shift of PhD to faculty level, when women are severely cut off from the academic path. More investigations are required to understand the reasons behind this phenomenon.

Figure 2 displays the proportion of students (both master's and PhD) and professors in Brazilian PPGs by gender, from 2013 to 2022. One can notice that the proportion of women has increased slightly in the past 10 years, but this rate is far from ideal.

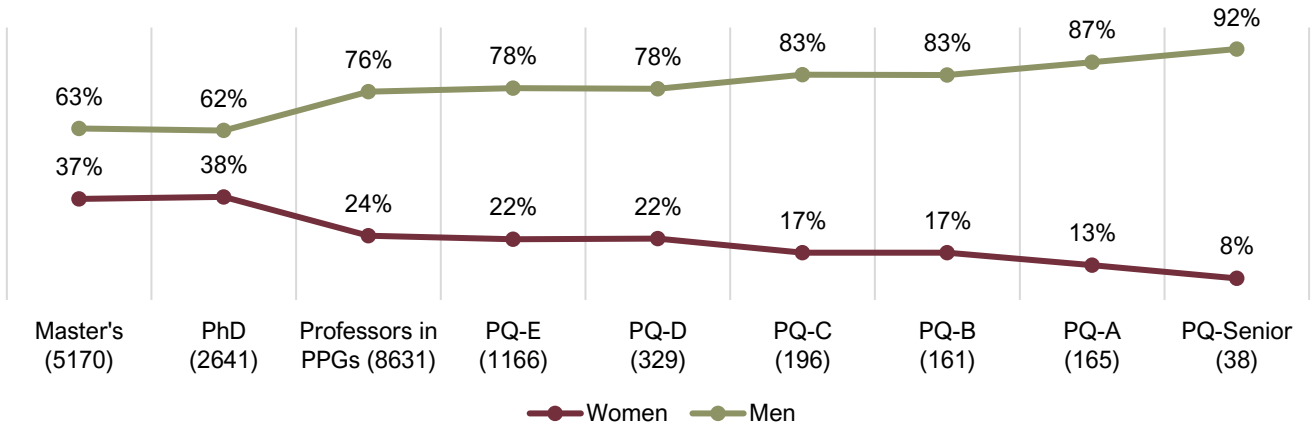

Figure 3 – Gender proportion of master's and doctoral students, faculty in Brazilian postgraduate programs (PPGs), and PQ grant holders (absolute total values in parentheses). Values for August 2022.

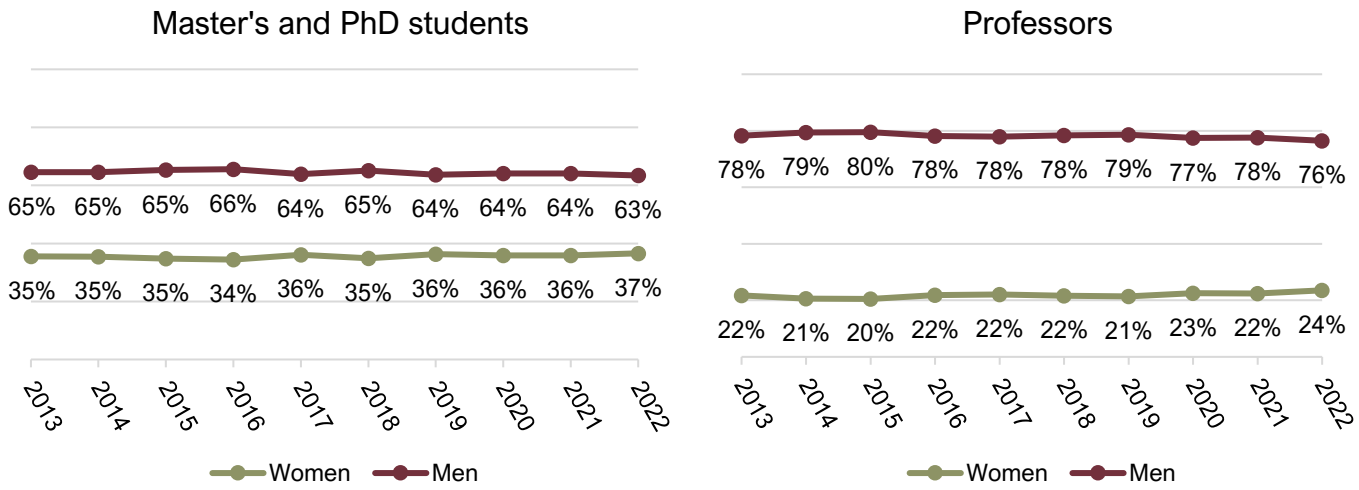

Figure 4 – Proportion of master's and PhD students (left) and professors (right) in Brazilian PPGs based on gender over the years.

These results show the overwhelming gender gap in Engineering PPGs in Brazil. Increasing representation of women in STEM fields is pivotal for fostering diversity and driving innovation. To address this challenge, the implementation of public policies becomes crucial to encourage women to enter and persist in STEM careers. Early initiatives promoting girls' interest in STEM, providing mentorship during higher education, and fostering an inclusive work environment are essential.

CONCLUSIONS

The present work proves and highlights the persistent gender disparities in engineering academia in Brazil, revealing a progressive decline in female representation, starting at 37% on master's degree and decreasing to only 8% at the senior research level. This significant decline unmistakably marks the scissor effect.

Analyzing the past 10 years of reports on master's and PhD conclusions, we also observed that this gender gap, evident from the master's level, is not closing by itself. This finding signals an urgent need to address biases and barriers hindering women's progression in engineering. Special attention must be paid to the barriers women face when becoming faculty members, since the scissor graph indicated that this is the main

stage when women "leak" out of the research career track. Policies and strategies to remediate this effect must be implemented immediately if we seek to encourage gender equality in the academic field.

ACKNOWLEDGEDMENTS

The research reported in this paper was supported by CAPES under Grant 88881.744259/2022-01; CNPq (PQ grant for Julia Mendes), PROPP/UFJF and PROPPI/UFOP. We would like to express our gratitude for their financial support, which made this work possible. The authors used ChatGPT to assist in translation and grammar check. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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CAN FEMALE PROTAGONISM IN INDIGENOUS COMMUNITIES FAVOR SUSTAINABILITY IN CONSERVATION UNITS?

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ABSTRACT

The participation of indigenous women as community leaders in Brazil has increased in recent decades. Promoting gender equality and the empowerment of women is a critical issue for sustainable development, proposed as a goal in the 2030 Agenda of the United Nations - UN. Therefore, the role of women in traditional communities is a key theme for sustainable development, especially in conservation units, that may contribute to the conservation of biodiversity and environmental services. The objective of this study was to investigate the profile of studies carried out in indigenous communities in the territory of Conservation Units in Brazil and identify how female protagonism favors sustainability. To achieve this objective, we surveyed literature data on the role of indigenous women in indigenous communities in Brazil within Conservation Units. As a result, positive correlations were found between the promotion of female empowerment, forms of female protagonism, and sustainable environmental practices in communities. Thus, the participation of women in traditional communities is one of the efforts to be considered as a path to sustainable development in Conservation Units.

Keywords: Indigenous women; gender equity; sustainable practices; ecofeminism.

INTRODUCTION

In the 1990s, indigenous women entered public spaces in a complementary way alongside men, through joint struggles about general issues related to their peoples, especially territoriality [1]. In the 21st century, with the growing female empowerment resulting from various political movements of resistance, these women began to gain attention in public spaces, in the organization, and as community leaders and they also included gender issues, women's rights and violence against women in their discourses [2]. At the same time, the anthropic disturbances caused mainly by the predatory exploitation of wood and the imposed demarcation of Indigenous Lands induced these peoples to create a new “ecological practice” that intensified the sustainable use of their delimited territories [3]. Thus, the struggle of indigenous peoples in favor of environmental sustainability grew as a simple matter of survival. Historically, different sustainable practices have been developed by these peoples, resulting from their intrinsic relationship with nature and the wisdom of observing nature’s responses. Such practices go from rotational extractions that respect the recovery time of the explored area to differentiated agricultural practices similar to agroforestry systems [3]. The development of these practices was also influenced by the women's actions and empowerment, their knowledge, and their concerns about ensuring the well-being of their peoples [4]. On the other hand, there are communities in which women still face several gender-related issues, accepted as the roots of their culture [5]. Female protagonism and sustainable development represent the ecofeminist movement that defends the conservation of the environment as an essential part of the feminist movement [6]. [7] studied this movement in an indigenous community of the Krahô ethnic group and found that indigenous women have a sacred relationship with sustainability and diversity so much so that this generates a commitment in their cycles, generations, and in the elaboration of public policies. As a matter of fact, during the study of two indigenous communities, [8] found that indigenous women presented different alternatives of social organization of low environmental impact linked to the principles of ecofeminism that strengthens the sustainable development of these communities. Thus, the objective of the present study was to investigate the profile of indigenous

communities in the territories of Conservation Units (CU) in Brazil in order to identify the relationships between female protagonism and sustainable development in these territories. This approach will broaden the understanding of this relationship between the participation of indigenous women and the sustainable development in territories of Conservation Units.

MATERIALS AND METHODS

CREATION OF THE DATABASE

Data were obtained through a literature review. Works (articles or theses) were selected using the Google Scholar search engine, through advanced search. The following specific keywords were used: “Unidade de Conservação” and “Mulheres indígenas”, occurring in any part of the text. Works published from 2006 to November 2023 were included, which resulted in a total of 279 works. Then, the inclusion criteria were: works that had data from at least one indigenous community in Brazil located within or near a Conservation Unit and which contained information about the role of indigenous women in the communities. Thus, a total of 42 works containing information from 44 indigenous communities located in different regions of the country were included. Also, a 2003 work on the indigenous community of the Pipipã ethnic group of Floresta, Pernambuco, was added [9]. Floresta is the place where the authors of this abstract develop a series of works on the knowledge and conservation of the local flora. Therefore, a total of 45 indigenous communities were evaluated in this study. A database was created with characteristics of the selected studies, namely: theme addressed in the study, Brazilian region, and other pieces of information. Several data from indigenous communities that included the participation of women were also included (Table 1).

Table 1 – Evaluated characteristics of Brazilian indigenous communities to verify the relationships between the activities of indigenous women in communities and sustainable development in Conservation Units. Source: The authors.

Characteristics	Category	Data
Main income activity in CU	Agriculture; Use of natural resource; Other income	Binary (0,1)
Mode of relationship with nature	Extractive or Sustainable	Binary (0, 1)
Solutions for environmental conservation	Absent; Other activity; Training; Practice	Categorical (0, 1, 2, 3)
Encouraging female empowerment	Yes or No	Binary (0,1)
Female protagonism	Absent; Individual; Leadership; Group	Categorical (0, 1, 2, 3)

DATA ANALYSIS

For data analysis, the percentage of each piece of information recorded was projected in pie charts. Also, a non-linear Principal Component Analysis was employed using the Gifi package in the RStudio program to investigate the profile of communities regarding the role of indigenous women in the communities and its relationship with sustainability and conservation of natural resources in Conservation Units.

RESULTS

First, regarding the analyzed studies, it was found that the efforts were mainly focused on indigenous communities in the North (40%) and Northeast (31%) regions of Brazil. The studies reported firstly social (49%) themes of the way of life of these communities and secondly the relationship of these communities with environmental issues and sustainability (20%). Regarding the profile of the communities, the PCA showed a satisfactory variance, accumulated in 60.46% in the first two axes (Figure 1). The characteristics that were most correlated with axis 1 were: Mode of relationship with nature: Sustainable (0.88), Solutions for environmental conservation (0.85), Female empowerment (0.65) and Female protagonism (0.51), also indicating a contrary direction to the Mode of relationship with nature: Extractive (-0.81). In turn, the characteristics most related with the axis 2 were the type of income, showing inverse directions between income from natural resources (-0.91) and income from agriculture (0.78). In other words, more effective the female protagonism of indigenous women in their communities is, this positively implies the sustainable development of the community and its sustainable relationship with nature.

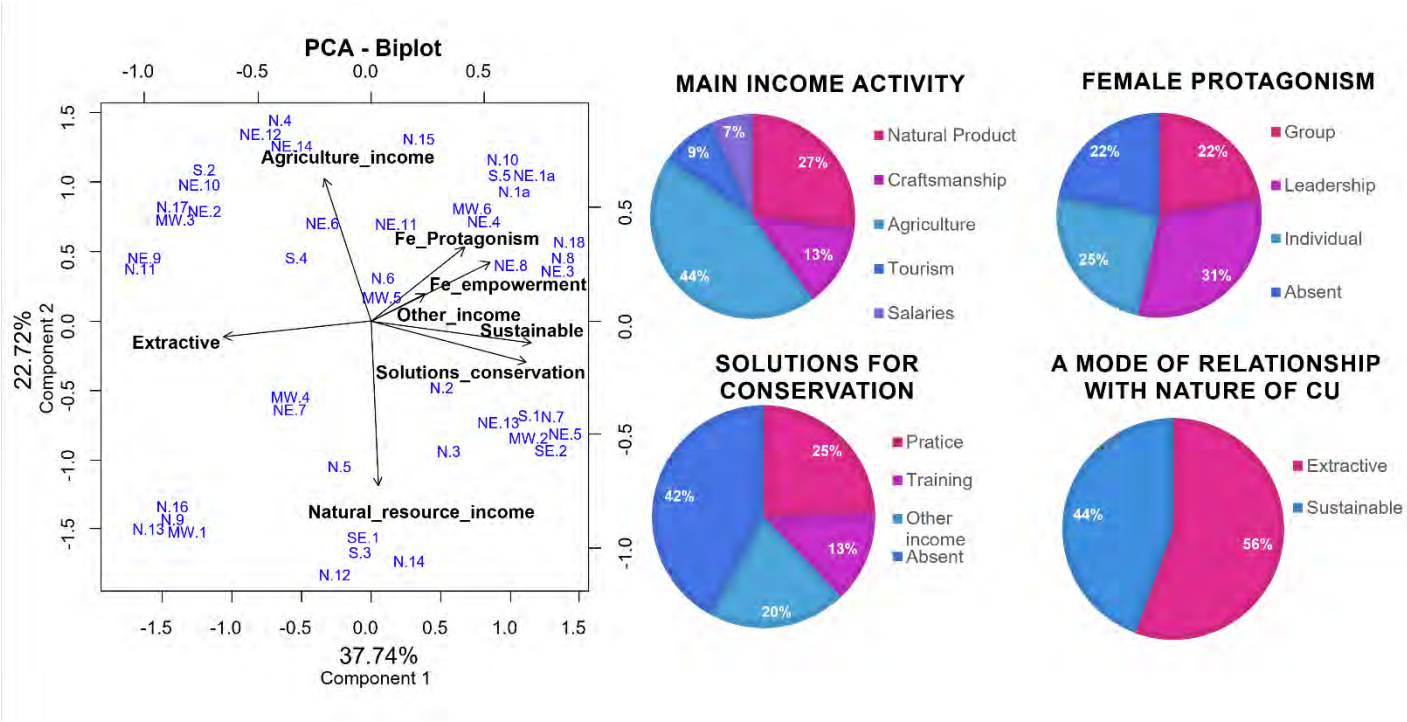

Figure 1 – Graphic ordination of the non-linear Principal Component Analysis (PCA) to verify the relationships between the evaluated characteristics regarding the participation of indigenous women in communities and sustainable development in Conservation Units in different regions of Brazil: North (N), Northeast (NE), Midwest (MW), [L1] Southeast (SE) and South (S).

CONCLUSIONS

The results obtained indicate that the active role of indigenous women in their communities as protagonists of their history and in the defense of their peoples is associated with sustainability and favors the very maintenance of the communities and their relationship with the environment, especially with regard to the sustainable use of natural resources. Although around 56% of communities have a sustainable relationship with nature that favor the conservation of the environment, another important portion of these communities still need encouragement regarding the adoption of more sustainable practices and female empowerment in a harmless way to their culture but which promotes the sustainability of the community and the relationship with the environment in the territories of these Conservation Units.

ACKNOWLEDGEDMENTS

The authors thank the Science and Technology Support Foundation of Pernambuco (FACEPE) for the financing of the APQ 1554-2.05/22 project whose mission is to understand and harmonize the conservation of plant biodiversity and human uses in conflicting territorial conservation zones and indigenous peoples, which gave origin to the idea of better understanding the relationship between the participation of indigenous women and sustainability in Conservation Units. Also, the English version of this article was produced by a human translator (Lisi Damáris Pereira Alvarenga) and made use of the open source web-based CAT tool Matecat for translation memory editing and glossary management.

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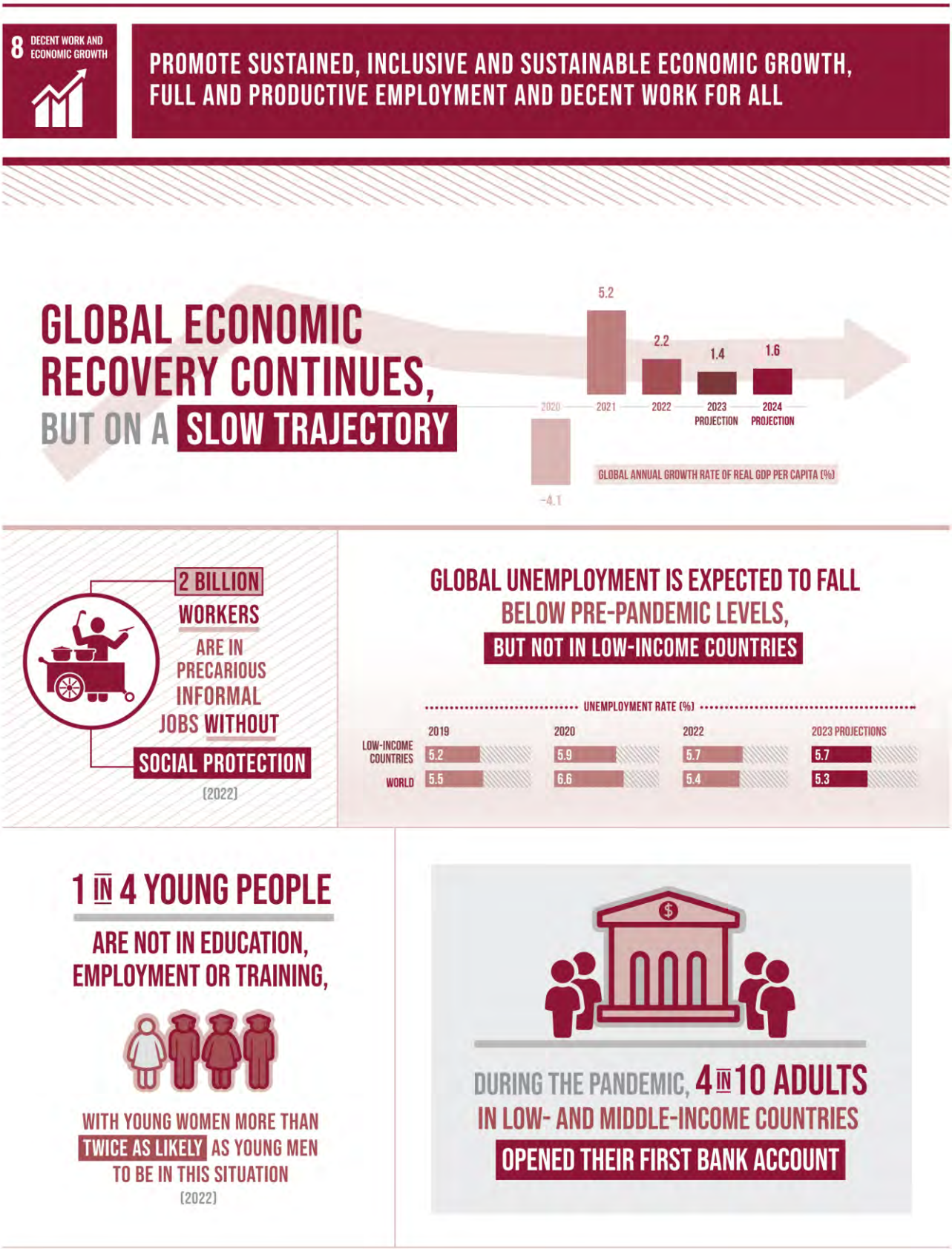
GOAL 8: PROMOTE SUSTAINED, INCLUSIVE AND SUSTAINABLE ECONOMIC GROWTH, FULL AND PRODUCTIVE EMPLOYMENT AND DECENT WORK FOR ALL



Source: UN's The Sustainable Development Goals Report 2023 – Special Edition

SUPPLY CHAIN RISK ANALYSIS BASED ON SUPPLY CHAIN OPERATIONS REFERENCE MODEL AND FAILURE MODE AND EFFECT ANALYSIS METHOD (CASE STUDY: ALAMENDAH TOURISM VILLAGE IN BANDUNG DISTRICT, INDONESIA)

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ABSTRACT

This research specifically explores risk analysis in the tourism supply chain of Alamendah Tourism Village in Bandung Regency, Indonesia, with the aim of supporting tourism service sustainability moreover after the Covid-19 pandemic. The analysis covering the hybrid modification of the Supply Chain Operations Reference (SCOR) model; Risk Breakdown Structure (RBS), Risk Breakdown Matrix (RBM), and Failure Mode and Effect Analysis (FMEA) methods to identify risk items and to mitigate 26 out of a total of 50 that were found to potentially disrupt the supply chain and then impact its Key Performance Indicators (KPIs). The findings identified 15 key risk areas that were utilized to establish recommended mitigation strategies including build contingency planning, held language training for tour guides, and improve communication with stakeholders. By implementing these strategies, Alamendah Tourism Village might increase its operational resilience and environmentally conscious actions especially to indicated critical risks therefore we provides a comprehensive study to the development of sustainable tourism practices through a scientific approach to risk analysis and mitigation in the tourism supply chains.

Keyword: Tourism Supply Chain Risk, SCOR, RBS, RBM, and FMEA

INTRODUCTION

Tourism is a temporary trip with the objective of seeking happiness, harmony, and balance in natural, social, and cultural aspects. Involving a variety of activities, tourism is supported by facilities and services from numerous parties, including the community, entrepreneurs, central, and local government [1]. As an important economic sector at both global and national levels, the tourism industry in Indonesia in 2023 showed a strong recovery after the pandemic, showing positive and constructive signals to bounce back to the previous era before the spread. While not yet reaching pre-pandemic levels, the tourism sector's contribution to GDP is exhibiting an optimistic trend, reflected in its potential growth and vital role in Indonesia's economy [2]. The illustration on the tourism contribution sector to Indonesia GDP (Gross Domestic Product) in 2018-2023 can be seen in Figure-1.

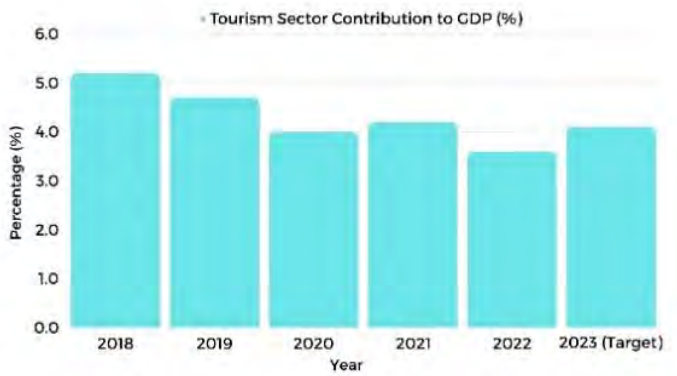

Figure 1 - Tourism Sector Contribution to GDP. Adapted from [3].

As of September 2023, the tourism sector's contribution to Indonesia's GDP stood at 3.83%, below the target of 4.1%, despite recovering from the impact of the pandemic. Sustainable tourism is recognized as an important trend, with the Ministry of Tourism and Creative Economy emphasizing tourists' awareness of responsible travel. The implications of sustainable tourism include environmental, cultural, social, and local economic aspects, in line with the SDG (Sustainable Development Goals) 8 that is to promote sustainable tourism. The 2030 sustainable development agenda emphasizes the importance of sustainable tourism, particularly in SDG 8.9 and 12.b which highlight the development of tools to monitor the impact of sustainable development on tourism [4]. In this context, tourism supply chain risk management (TSCRM) becomes a crucial strategy to identify and mitigate risks regarding information circulation, raw material quality, and privacy [5]. This research is conducted to analyze the risks of the tourism supply chain in Alamendah Tourism Village in Bandung Regency, as one of few developed village in Indonesia according to the Ministry of Tourism and Creative Economy (Kemenparekraf), in order to identify the risks which are related to its supply chain that would probably occur, then continued with the strategies formulation to mitigate them.

MATERIALS AND METHODS

TOURISM SUPPLY CHAIN RISK MANAGEMENT

Supply chain in tourism, known as Tourism Supply Chain (TSC), encompasses various functions within the travel and tourism industry, including tourist attractions, transportation, accommodation, shopping centers, travel agents, and service suppliers [6]. Risk, defined as potential events leading to loss or danger, involves unexpected adverse occurrences [7]. Risk management, a systematic science, aims to identify, measure, and mitigate risks, thereby minimizing negative impacts and maximizing opportunities for organization [8].

SUPPLY CHAIN OPERATIONS REFERENCE MODEL

SCOR, or Supply Chain Operations Reference, delineates business activities across organizational levels to meet customer demands and improve supply chain effectiveness. Through indicators like Reliability, Responsiveness, Cost, and Assets; SCOR enables performance evaluation and optimization across six main processes of Plan, Source, Make, Deliver, Return, and Enable functions within supply chain management [9].

RISK BREAKDOWN STRUCTURE

Risk Breakdown Structure (RBS) hierarchically organizes risks within organizational or project structures to enhance understanding and systematic management. It is a well-known tool for organizing risk processes and often incorporated into standards and guidelines [10]. Following RBS, the Risk Breakdown Matrix (RBM) assesses identified risks, presenting them in a matrix format to prioritize based on impact and likelihood, aiding in urgent risk identification [11].

FAILURE MODE AND EFFECT ANALYSIS

Failure Mode and Effect Analysis (FMEA) is a systematic method applied in risk management to evaluate and identify the causes and effects of failure in a process or system. FMEA is a structured procedure used to recognize possible failure modes and preventive measures [12]. The main purpose of using FMEA is to identify potential risks and their impact on the process or product, and plan actions to reduce the risk of failure [13].

RESULTS

BUSINESS PROCESS IDENTIFICATION

A business process consists of interrelated actions aimed at achieving organizational goals, enhancing productivity, resource utilization, and overall performance [13]. Risk identification entails evaluating the impact and likelihood of potential risks on key processes, prioritizing those with the highest impact and likelihood for mitigation.

SUPPLY CHAIN RISK IDENTIFICATION

Identifying risks in the supply chain involves determining and documenting risks that affect production, distribution, and service. Risks can stem from delivery delays, supply shortages, price changes, and regulatory changes. Risk identification at each SCOR stage of Alamendah Tourism Village resulted in 50 potential risks. After validation, 26 risks were found that could potentially disrupt the supply chain. At this stage, the RBS method was used with 3 levels: Level 1 categorizes risks based on activities covering Plan, Source, Deliver, and Enable main processes of the tourism supply chain. Level 2 categorization, following the aspects outlined in Level 1, encompasses categories such as marketing, social, operational, logistics, political, financial, human resource management, communication, environmental, economic, procurement, and cultural factors. For Level 3, risks potentially occurring are listed during the risk identification process in the tourism industry, similar to service-based industries.

Table 2 - Supply Chain Risk Identification Results

Level 0	Level 1	Level 2	Level 3
Risk for each SCOR Model process	Plan	Marketing	- Miscalculation of the number of tourists to procure tourist needs - Failure in New Product Development - A difference in the number of tourists predicted compared to real conditions
		Social	- Changes in the needs of tourists

RISK ASSESSMENT

After identifying risk items within each process, the risk assessment proceeds by administering a questionnaire to experts, employing a structured judgment method. Utilizing the FMEA method, which is based on three aspects: the severity of the risk's impact on the supply chain, the detection capability, and the likelihood of occurrence; a Risk Priority Number (RPN) value can be determined. The value defines the risks that require prioritization for mitigation. Meanwhile, the risk assessment using RBM will illustrate the impact of risks in Alamendah Tourism Village on various Key Performance Indicators (KPIs).

Table 3 - Risk Priority Based on Risk Priority Number (RPN) Value

No.	Risk
1	Weather Change
2	Sustainable Human Resources or Royalties from Human Resources
3	Lack of foreign language knowledge of tour guides
4	Changes in the number of human resources used
5	Changes to the point schedule when traveling

RISK MITIGATION

Risk mitigation strategies were formulated based on the results of risk assessments using the FMEA method and through Focus Group Discussions (FGDs). These discussions yielded mitigation strategies for priority risks. Effective measures include developing human resource management, implementing contract policies for sustainability, providing foreign language training for guides, reviewing tourist numbers, offering indoor activities, and ensuring weather-related equipment provision and routine facility maintenance. These strategies aim to enhance operational resilience and tourist satisfaction, minimize risk impacts, to the village.

CONCLUSIONS

There are 50 potential risks that can disrupt the supply chain in the observed tourist village based on the SCOR model and the Risk Breakdown Structure method. After conducting the validation process, 26 risks were obtained that is known to potentially occur there. Referring to the results of the FMEA method, 15 risks are prioritized for risk mitigation. In addition, seeing the Risk Breakdown Matrix, the risks are confirmed to have an impact on the village's KPIs if not managed properly.

ACKNOWLEDGEDMENTS

The authors would like to thank Alamendah Tourism Village for their help and great cooperation, and Cheryl Suciyanti Putri for conductiong the first stage of our group research roadmap. This study was funded by Universitas Pertamina through UPEResearch 2023 scheme. All these contributions have been invaluable and have enriched this research.

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DEVELOPMENT OF CIRCULAR CITIES: A SWOT ANALYSIS

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ABSTRACT

Cities are hotspots of consumption and waste generation. In order to reduce the negative impacts of cities and help achieve urban sustainability, the Circular Economy (CE) has been encouraged and implemented in several cities worldwide. In this scenario, the idea of Circular Cities (CC) arises. A CC incorporates the principles of the CE as part of its development and operation. This work aims to identify the strengths, weaknesses, opportunities and threats in the development of CC. To this end, we conducted a literature review and analyzed the circular city strategy of pioneering cities in CE. Then, we constructed a SWOT matrix. The SWOT matrix is a tool that facilitates the visualization and understanding of important information in a process, allowing the identification of points that need to be improved. This study is helpful for urban managers to elaborate plans for CE in cities and achieve SDG 11 (sustainable cities and communities).

Keywords: Circular Economy; Circular City; Urban Sustainability, SWOT analysis.

INTRODUCTION

The Circular City (CC) concept is still under development in academic literature. For Girard and Nocca [1], a CC is a metaphor for a new way of looking at and organizing the city. The authors argue that the idea is that the linear processes of cities can be (partially) replaced by circular processes. In other words, the idea of extracting, producing and discarding that comes from linear thinking no longer exists in cities. Thus, all urban infrastructure and services (water supply and treatment, energy, waste management, transportation) will be designed with CE in perspective.

In this sense, for the Ellen MacArthur Foundation (EMF) [2], a CC can eliminate waste, reduce pollution, reduce carbon emissions, keep materials in use and reduce pressure on natural resources. CE in cities has the potential to transform urban areas into centers of prosperity, boosting economic growth by fostering local production and creating new business opportunities and jobs. Cities have had positive experiences with CE. Paris, for example, has adopted a circular approach to the circulation of building materials, food, and water and has achieved good results by reducing waste related to these sectors [6].

Despite the benefits, the development of CE must be studied since the implementation of CE on an urban scale is complex and must consider the interconnection of various material flows, stakeholders and sectors [3]. In this way, identifying the strengths, weaknesses, opportunities and threats of the transition from linear to circular cities can facilitate decision-making by urban managers and prevent them from making mistakes and hindering this transition. Many of the opportunities, advantages, benefits and challenges of developing CC have already been identified in academic literature. However, there is a need to convey scientific knowledge clearly to urban managers.

SWOT analysis (strengths, weaknesses, opportunities and threats) is a cognitive subjective-objective evaluation procedure that examines the interactions between the internal and external environments that can impact an organization, territory, sector or process [4]. As highlighted by the acronym, the SWOT recognized strengths, weaknesses, opportunities and threats to achieve the proposed objective [5]. The SWOT matrix generated through the analysis facilitates the visualization and synthesis of information and can effectively transmit the knowledge contained in scientific texts to urban managers.

This study aims to identify the strengths, weaknesses, opportunities and threats in the development of CC and construct a SWOT matrix that assists urban managers in the decision-making process.

MATERIALS AND METHODS

A literature review was conducted to identify the strengths, weaknesses, opportunities, and threats in the development of CE and thus construct the SWOT matrix. The authors selected articles that identify the challenges, barriers, opportunities, and benefits of CE in cities. To complement the review, we included documents elaborated by the EMF, which has been publishing materials on CC. The EMF papers were selected because of the organization's pioneering work on CE.

In addition, the authors identified pioneering cities for implementing CE on an urban scale. These cities were Paris, Rotterdam, Helsinki, Prague, Copenhagen, Amsterdam, and London. All are on the European continent, at the forefront of transitioning to a circular and sustainable economy. Figure 1 presents details of each step of the methodology used in this work.

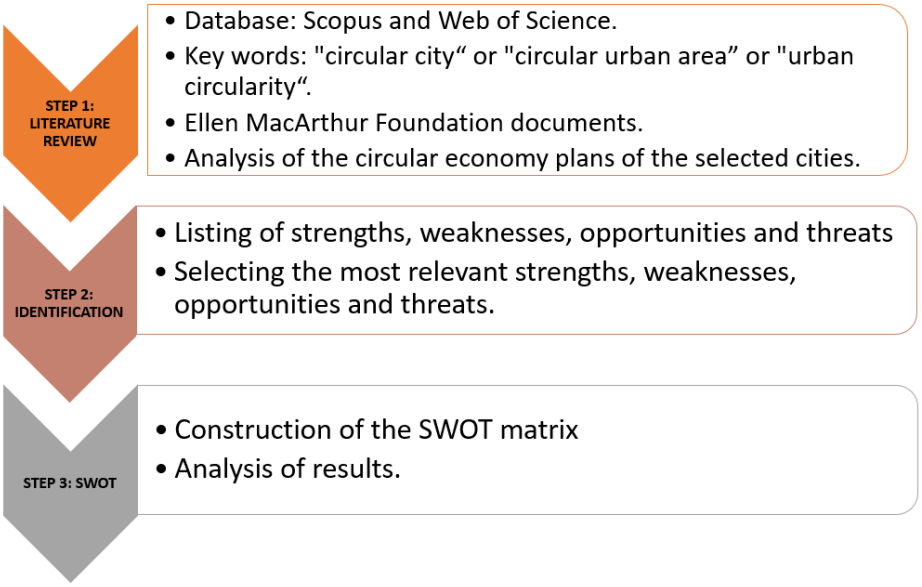

Figure 5 - Methodology used in this work.

RESULTS

Through the literature review, we identified the relevant authors for this study. These authors are Ellen MacArthur Foundation [2], Paiho *et al.* [3], Williams [6], Christensen [7] and Campbell-Johnston *et al.* [8]. This analysis considered these papers because, although they did not directly use the words "strengths, weaknesses, opportunities and threats", they pointed out the challenges, barriers, opportunities and benefits of developing CC so it possible to construct the SWOT matrix shown in Figure 2.

Cities' strengths in promoting CE are related to their autonomy to create regulations, plans and strategies to encourage the circular transition, having a physical infrastructure, and coordinating the provision of services (waste management, energy, sanitation, transport) with circularization potential. City administration can also facilitate identifying and engaging key players for the circular transition in cities [1], [2], [6], [7].

The weaknesses of cities are related to the internal and current challenges that make it difficult for cities to seek to become circular. This study identified that the main challenges are the lack and complexity (urban circularity involves different sectors and urban actors) of public policies to create an environment that encourages the development of CE [8]. In addition, there is no clear definition of a CC, so each city interprets

and implements CE differently [1]. The studies analyzed also report the need for knowledge about CE and the flows of materials circulating in cities [3]. It is also pointed out that the need for monitoring and management tools is a weakness of the urban circular transition [1].

The main opportunities related to the development of CC are creation of jobs and income, improvement in the quality of life of the population (due to better air quality, improvement in urban transportation, strengthening and empowerment of local communities, etc.), reduction in waste generation (extension of the useful life of products, repair initiatives, sharing of products), reduction in GHG emissions, reduction in the extraction of natural resources and negative impacts on the environment (leading to ecological regeneration, increase in green areas and biodiversity) [2], [3], [6], [7], [8].

Finally, the external threats that hinder the development of the CC are the lack of interest from companies and the population in participating in the circular transition, the lack of shared responsibility and communication between those involved in the circular transition project (these facts can make it impossible to implement the CE plans), the persistence of linear thinking (especially during urban planning), the lack of external funding (companies and higher levels of public administration) can be an obstacle for cities that intend to be circular [3], [7].

Figure 6 – SWOT matrix for the CC development.

City administration representatives worldwide can consult the SWOT matrix constructed in this work. Consulting this matrix will facilitate the decision-making process about the development of CCs. It will make it easier to find solutions to the weaknesses and threats highlighted in the matrix. In addition, the matrix can be used to monitor the process of creating CCs as it can be consulted periodically to, for example, identify whether weaknesses have been overcome.

Even though there are several weaknesses and threats, the benefits of implementing CE and developing CCs are evident. They can contribute to building socially just, environmentally preserved and economically stable cities. All the cities analyzed in this study reported the positive impact of creating a CE strategy to achieve the

city's sustainability. In this way, CCs can contribute to achieving some SDGs, such as SDG 6 (clear water and sanitation), SDG 7 (affordable and clean energy), SDG 8 (decent work and economic growth), SDG 12 (sustainable production and consumption), SDG 13 (climate action) and the especially SDG 11 (sustainable city and society).

To ensure that CE contributes effectively to achieving these SDGs and to overcome the weaknesses and threats presented in Figure 2, the following actions are suggested: creating a holistic, long-term strategy for CE in cities, involving all stakeholders in the process of developing CE, constantly monitoring and evaluating circular initiatives, establish a set of indicators to help assess circular initiatives, investing in awareness-raising initiatives for all stakeholders, integrating a circular vision into urban planning, creating a funding structure for circular initiatives.

CONCLUSIONS

This work sought to construct a SWOT matrix on the development of CC. Identifying and synthesizing the opportunities, strengths, weaknesses and threats of CC is essential for city managers to have access to academic knowledge about CC. In addition to providing a holistic view, understanding the current situation of the circular transition process in cities sheds light on the possible challenges of implementing a CE strategy. The matrix can also be a monitoring tool as a city sees progress towards building CE.

This work has achieved its objective and will facilitate decision-making by urban managers involved in the circular development of cities. Even with various barriers and challenges, implementing CE in cities is essential to achieving urban sustainability and meeting the objectives of SDG 11.

ACKNOWLEDGEDMENTS

The authors would like to thank CNPq, FAPEMIG and CAPES for their financial support for the projects that supported this work's development.

The authors used Grammarly to check grammar issues and improve readability.

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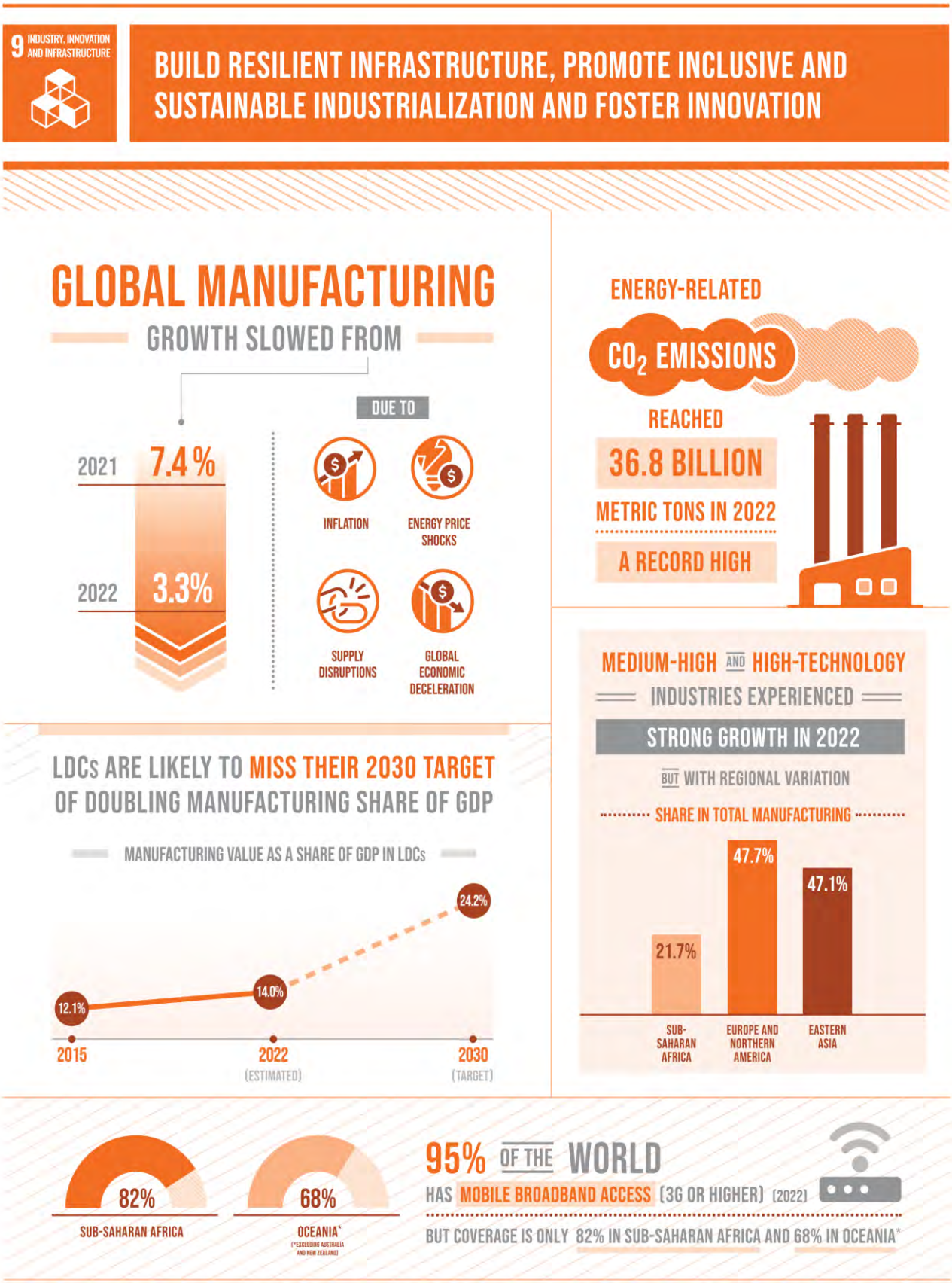
GOAL 9: BUILD RESILIENT, PROMOTE INCLUSIVE AND SUSTINBALE INDUCTRRIALIZATION AND FOSTER INNOVATION



Source: UN's The Sustainable Development Goals Report 2023 – Special Edition

INFLUENCE OF DATASET VARIABILITY WHEN PREDICTING CONCRETE COMPRESSIVE STRENGTH WITH MACHINE LEARNING

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ABSTRACT

Concrete is one of the most used materials in the construction industry, but it also responds for high environmental impacts. In this sense, Machine Learning (ML) has been used to optimize material consumption through models that are capable of understanding the relationship among concrete components and its strength. The compressive strength is an essential property in structural design, but the heterogeneity of concrete components makes its prediction extremely difficult. In this scenario, the present work investigates the influence of the heterogeneity of concrete in the ability of a ML model to predict its compressive strength. The authors created 7 different datasets with data from 3 Brazilians Universities and used a XGBoost model for strength prediction. The coefficient of determination of the models (R^2) varied from 0.47 to 0.89, but the model that achieved 0.89 was probably overfitted. The low accuracy of some models prevented the authors to achieve the objective of this project. These results suggests that the variability of the concrete materials and the size of the dataset are still significant challenges to the use of AI in concrete mix design.

Keywords: Machine Learning; Concrete Strength; Concrete Dataset; Concrete Mixture.

INTRODUCTION

Concrete is a construction material widely used worldwide. It presents relatively low cost, availability, and durability, but it also produces significant environmental impacts, such as high emission of greenhouse gases [1] and high demand of natural resources. Engineers design concrete structures with a specific compressive strength class. This strength will be met using a certain proportion (mix) of Portland cement, aggregates, water, and admixtures, according to standardized mix design techniques. After concrete pumping, a laboratory test is usually conducted to ensure that the concrete attains the designed strength within 28 days. The main challenges to obtain an optimized mix proportion are a) the empirical nature of mix design techniques (usually based on charts and experimental formulae); b) the time and resources required to test the concrete mixes; and c) the heterogeneity of the available components in each region, especially the cement and aggregates.

The UN's Sustainable Development Goals 9, 11 and 12, encourage resilient infrastructure, sustainable cities, and responsible production. The development of sustainable, safe, and effective strategies to design concrete mixes is integral to a sustainable future worldwide, reducing the consumption of natural resources. To promote this objective, numerous researchers have experimented machine learning (ML) models aimed at predicting the compressive strength of concrete from its components [2] [3] [4].

ML is a branch of artificial intelligence (AI) that involves computational algorithms that use prior knowledge (data) to generate autonomous predictions. These prior investigations yielded promising results but were done with databases (concrete mix proportions) sourced from the literature. Such databases may not accurately represent the specific region for which compressive strength predictions are sought. In some cases, the authors themselves recognized that the variability of the concrete mixes from around the world impaired the quality of the model [4]. Ideally, ML models should be trained with a dataset that faithfully mirrors the local material specifications, ensuring a more accurate and region-specific prediction of compressive strength.

Numerous studies have demonstrated commendable accuracy in strength predictions, affirming the potential of these techniques to significantly reduce time and resource consumption [5]. However, no article was found investigating how the characteristics of the dataset influences the prediction quality. In this context, the objective of this work is to assess the impact of the dataset variability on the accuracy of a ML model in predicting concrete strength.

MATERIALS AND METHODS

Initially, we created a database with 121 concrete mixtures from 3 Brazilian Universities situated in the state of Minas Gerais. Each mix (1 instance or observation) includes the amount of concrete components (i.e., Portland cement, coarse aggregate, fine aggregate, water, chemical and mineral admixtures; in kg/m³) and their respective compressive strength (varying from 15 to 50 MPa). Each university adopts certain types of aggregates and production process. They obey the same Brazilian standard for concrete production and are located in the same macro-geological region, but each has its own particularities regarding the preparation of specimens.

The data underwent thorough processing and cleansing, eliminating mixtures that did not align with real-world scenarios. Subsequently, the authors split the database into 7 datasets (see Table1), by combining the three primary datasets to investigate the impact of their variability on the model's accuracy. All datasets were tested using the XGBoost model and employing cross-validation (10-fold) to assess their accuracy in establishing relationships between input data (concrete mix components) and output (concrete compressive strength). Further details about the model can be found in [2]. Their performance was evaluated using three metrics: coefficient of determination (R^2), Mean Absolute Error (MAE), and Root Mean Square Error (RMSE) [2].

Table 4 – Number of mixtures per dataset. Source: authors.

Dataset	UFJF	UFOP	UFV	UFJF+UFOP	UFJF+UFV	UFOP+UFV	UFJF+UFOP+UFV
Number of instances	39	51	31	90	70	82	121

RESULTS

Figure 1 presents the metrics of each one of the 7 models. The UFJF model emerged as the standout performer, attaining the highest R^2 of 0.89. This model also presented the best result for the other metrics. In contrast, the UFV model exhibited the poorest performance, achieving an R^2 of 0.47. The accuracy achieved by the UFJF model is similar to the results presented by [6] and [7]. The UFOP model, tested with the largest of the three primary datasets, presented worse-than-expected results, with a R^2 of 0.68. But it still outperformed the results presented by [2]. As the datasets are combined, the results reach an intermediate level (0.68-0.78).

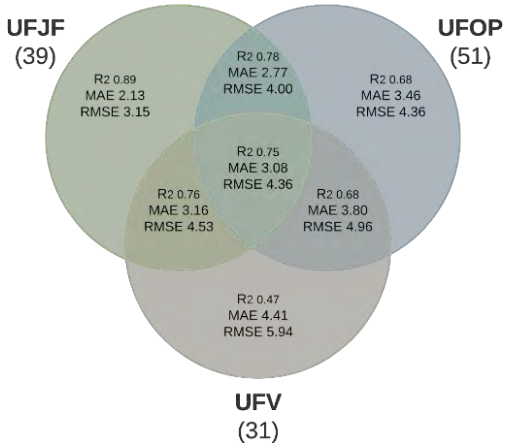

Figure 1 – Evaluation metrics of the models, combining the datasets from each university. Note: MAE and MAPE in MPa.

To help understand the variation on these results, the next figures exhibit scatter plots of the compressive strength versus the consumption of cement (Figure 2) and the water/cement ratio (Figure 3), for the primary datasets. From general knowledge, these are two of the most important variables influencing compressive strength.

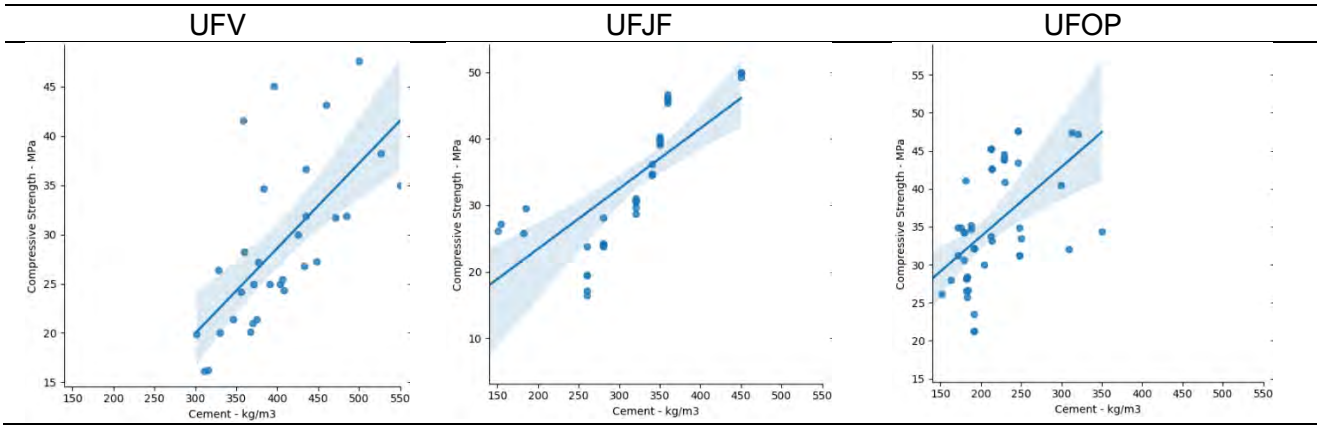

Figure 2 – Compressive strength x cement consumption for the primary datasets. Source: authors.

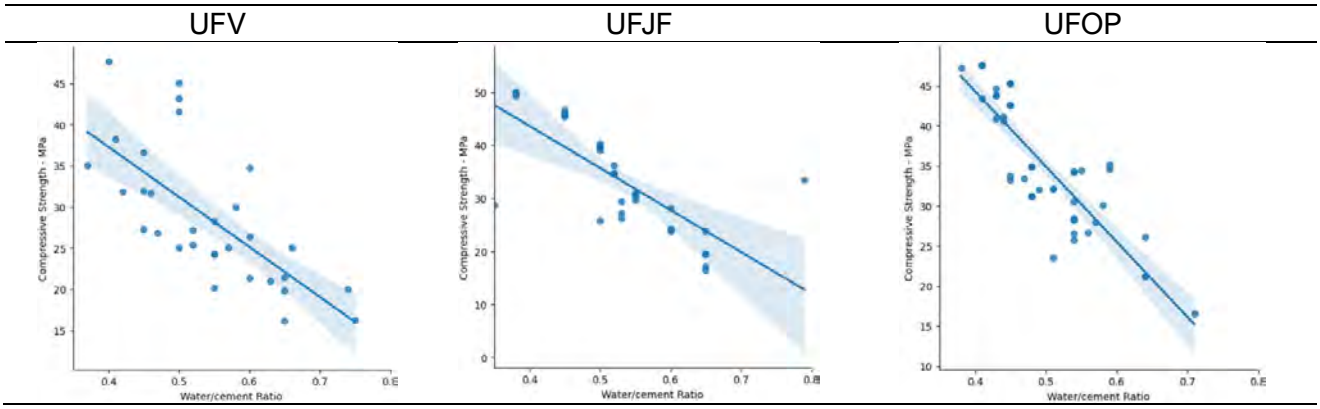

Figure 3 – Compressive strength x water/cement ratio for the primary datasets. Source: authors.

Notably, when data has low variation and similar points in certain variables, the training process involves similar mixtures. For instance, in the UFJF dataset, the consumption of cement mostly ranges from 250 to 350 kg/m^3 (low variation, the highest R^2 and lowest MAE and RMSE). In contrast, the UFV dataset exhibited greater dispersion, with cement consumption ranging from 300 to 500 kg/m^3, and fewer instances (leading to the worst R^2 and highest MAE and RMSE).

In broad terms, if generalization ability is desired, a more varied dataset is preferable [2]. However, in the present work, errors tended to be smaller in datasets with more concentrated points (UFJF). This phenomenon is probably a consequence of using cross-validation to assess the quality of the model. In the cross-validation technique, the mixtures adopted for evaluating the model are randomly extracted from the same dataset (in each iteration, 90% of instances are used to train the model, and 10% to test it). Because the UFJF dataset had low variability, the tested instances were similar to the ones used for training, leading the model to a false high R^2 and low MAE and RMSE. This dataset obtained great metrics, but it would not be able to represent all the variation of the variables in a real-world scenario. This behavior is called “overfitting”.

Conversely, in databases with wider range of mixes to learn from but fewer instances, as observed in the UFV dataset, there is limited data available for training the algorithm within each range of variation, leading to poorer predictions. This outcome could potentially be mitigated by increasing the amount of data in this dataset.

The same trend was noticed in the datasets created through the combination of the three primary databases. Although the variability of characteristics was enhanced, the broader range of variation coupled with a low quantity of data in each range diminished the training capacity of the models. As noted, some of the variables in Figure 2 and 3 range in different spaces. Consequently, the combined models presented intermediate results due to the challenge posed by the increased diversity and limited instances within each variation range.

CONCLUSIONS

The present work sought to verify the ability of ML models in predicting the compressive strength of concrete with gradually more varied datasets. The poor performance obtained in the primary and combined models were probably a result of the small number of available instances, what hindered the authors' goal to evaluate if the dataset variability would influence the accuracy of the model. We propose that further studies be undertaken with a larger and more varied dataset. Such an enhancement would render the model more representative and trustworthy in real-world applications. And then future projects could assess how the combination of different datasets influence the overall metrics of the ML model.

ACKNOWLEDGEDMENTS

The authors gratefully acknowledge the agencies FAPEMIG (Grant APQ-01838-21) and CNPq (grant 305818/2023-6 – PQ researcher – for Julia Mendes). We are also grateful for the collaboration of the Research Group on Data Science in Engineering (CIDENG – CNPq). The authors used ChatGPT to assist in translation and grammar check. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT THROUGH THE LENS OF ARTIFICIAL INTELLIGENCE: A SHORT REVIEW

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ABSTRACT

Construction and Demolition Waste (CDW) represents 30 to 40% of global solid waste. Recently, there has been an increase in research related to the management and recycling of CDW with the goal of mitigating its environmental impacts, some of them using Artificial Intelligence (AI). AI has been applied in the field to analyze large volumes of data concerning construction materials, their characteristics, and their recycling potential. The present study aims to identify how AI techniques are being employed in CDW management through a short literature review of 20 papers. The incorporation of AI in CDW management is relatively recent, with a significant rise in publications noted from 2021. Most papers have a Chinese first author, and the most frequently used ML algorithms were the RF, GBM, CNN, and ANN. Three primary research themes emerged: CDW Generation Prediction, CDW Classification and Identification, and Decision Support Systems and Logistics. Despite the advancements, the scarcity of data stands out as a significant impediment to building robust AI models. Future efforts should concentrate on overcoming data limitations, improving the interpretability of models, and integrating ML models with DSS and logistics to promote sustainability and circularity in construction practices.

Keywords: CDW; Construction; Artificial Intelligence; Machine Learning; Management.

INTRODUCTION

The construction industry wields considerable environmental influence, with 30 to 40% of the global solid waste stemming from construction and demolition waste (CDW) [1]. The improper disposal of CDW occupies significant landfill space and contributes to soil sedimentation and erosion if not managed appropriately [1]. Despite increased research efforts to manage and recycle CDW to mitigate its environmental impacts [2], especially as recycled aggregate, this residue is still discarded without reuse in many regions of the world [3].

Artificial Intelligence (AI) has recently played a substantial role in optimizing and automating various sectors in society [4]. In CDW management, AI proves valuable by analyzing extensive data on construction materials, their characteristics, and recycling potential [4]. Additionally, AI aids in predicting the amount of waste generated during building demolition, contributing to informed decision-making on waste recycling and disposal [5]. When coupled with tools like GIS (Geographic Information System), AI can identify optimal landfill areas, spot illegal disposal sites, and optimize waste logistics [6].

In this scenario, the present study aims to identify the application of AI techniques in CDW management through a short review. To guide this review, we formulated 3 research questions: (1) What are the primary current research topics in CDW management linked with AI? (2) Which algorithms are predominantly used in the field? (3) What are the main challenges and limitations in developing these models? By doing so, the study seeks to enhance understanding in this domain and encourage researchers and professionals to develop AI models for improving CDW management, contributing to UN's SDGs 9 - Industry, innovation, and infrastructure, and 11 - Sustainable cities and communities.

MATERIALS AND METHODS

To carry out this short literature review, we searched for relevant scientific papers using the Scopus database on April 15, 2023. The search string employed was "*(("construction and demolition waste" OR "construction waste" OR "demolition waste") AND management AND ("artificial intelligence" OR "machine learning"))*". As most journals indexed in the Scopus platform are in English and our study aimed for global coverage, the search was conducted exclusively in English. Only articles in the final publication stage were considered under the "document type," and review articles were excluded to focus on original publications. Additionally, conference papers were omitted since they are typically presented in journal article format.

The selected publication years spanned from 2018 to 2022 to capture the most recent contributions to the topic. In total, 20 studies met the specified criteria, and information such as publication year, country of origin of the first author, main models used, and primary gaps and limitations addressed were extracted from these articles. Our initial analysis involved a scientometric examination, including the evolution of publications over the years, leading countries in publication rates, and the most frequently used algorithms. Following this, a discussion was conducted on the principal research topics employing AI techniques in CDW management and the key challenges addressed by the authors in developing these models. It is crucial to note that the studies resulting from this research are confined to the searched terms and adopted criteria – the scientific merit or citation metrics of selected articles were not taken into consideration.

RESULTS

SCIENTOMETRIC ANALYSIS

Initially, we conducted a scientometric analysis from the 20 papers. Notably, the incorporation of AI in CDW management is a recent phenomenon, evidenced by a substantial surge in publications starting from 2021. Seven papers were published in 2022, while ten were published in 2021. Examining the geographical distribution of the publications, 40% of the articles had a Chinese first author. This aligns with previous research highlighting China's prominent role in AI research [7]. China is one of the main countries that publishes papers on the application of AI in Structural Engineering, alongside the U.S., Iran, and the U.K [7].

In terms of Machine Learning (ML) algorithms, the predominant ones employed across the articles were Random Forest (RF), Gradient Boosting Machine (GBM) – with variations like XGBoost considered in this category, Convolutional Neural Network (CNN), and Artificial Neural Networks (ANN).

MAIN RESEARCH TOPICS

Three primary research themes related to CDW management integrated with AI were identified in the papers: CDW Generation Prediction (8 papers), CDW Classification and Identification (6 papers), and Decision Support Systems (DSS) and Logistics (6 papers).

Predicting the volume and/or mass of CDW generated in construction sites, cities, or per year holds significant value for enhancing its management [3]. This knowledge aids in planning waste management facilities, analyzing the feasibility of shared landfills among neighboring municipalities, quantifying carbon emissions, and implementing various waste management strategies and policies [3]. Recent advances in AI techniques have led to the emergence of studies predicting CDW generation rates using ML. Among these, Artificial Neural Networks (ANN) are frequently employed due to the possibility of being applied in various kinds of problems with little data processing, allowing them to be integrated into other algorithms, creating hybrid tools [8]. However, they come with the drawback of being a "black-box" model, meaning researchers can visualize input and output data but struggle to interpret the internal workings [7]. This characteristic impairs interpretability and accountability, being a drawback for researchers and policymakers [9].

The classification and identification of CDW are pivotal in improving the management of this waste stream. This waste has a heterogeneous nature, usually mixing up concrete, mortar, wood, glass, ceramic materials, paper, among others [4]. This characteristic hinders CDW reuse due to the slow and costly manual separation process [4]. In this scenario, some authors have employed smart devices equipped with image recognition algorithms to automatically classify various types of CDW, streamlining the waste separation process, and making recycling more appealing [4]. Image recognition algorithms, such as CNN, were the basis for most of the CDW Classification and Identification papers.

Finally, DSS coupled with effective logistics play a crucial role in the efficient management of CDW. DSS offers a structured framework for data-driven decision-making, allowing stakeholders to analyze and interpret information related to CDW generation, composition, and disposal [6]. Interestingly, most of the studies addressing DSS and Logistics (five out of six) did not rely on ML but instead utilized mathematical simulations, optimization methods, and GIS.

MAIN LIMITATIONS ADDRESSED BY THE AUTHORS

Several authors highlighted the scarcity of available data as a key challenge. Dealing with an imbalanced dataset presents a noteworthy obstacle in classification tasks. When working with such data, ML models may develop biases toward the majority class, as global performance optimization often prioritizes accuracy in the dominant class [10, 9]. In response to the data scarcity issue, many authors resorted to collecting their own data, an approach that is not only costly but also time-consuming. This fact underscores the absence of a reliable database for such studies, resulting in models that are often limited to representing a specific region.

Regarding DSS and Logistics, three studies shared a common limitation by narrowly focusing on strategies to restrict construction materials, predominantly concrete. Notably, despite transportation costs and environmental impacts posing significant obstacles to CDW use, few studies delve into its logistics [3]. Consequently, a noticeable gap persists in effectively addressing logistical challenges in CDW management.

CONCLUSIONS

This study conducted a short literature review of 20 research papers to examine the application of AI tools in CDW management. This application is relatively recent, with a significant rise in publications noted from 2021. Most papers have a Chinese first author, and the most frequently used ML algorithms were the RF, GBM, CNN, and ANN. Three primary research themes emerged: CDW Generation Prediction, CDW Classification and Identification, and Decision Support Systems and Logistics.

Authors consistently highlight a major limitation: the inadequacy or poor quality of data, including issues like imbalance, faults, or lack of standardization. Insufficient data compromises the models' ability to generalize patterns, leading to inaccurate or biased results. This limitation also restricts the development of models applicable on a broader scale. Beyond the data challenge, many ML algorithms operate as black-boxes, making their operations and decision-making processes challenging to comprehend. This black-box issue is significant ethically, as understanding how an ML algorithm reaches significant decisions is crucial for building trust in such systems and promoting widespread AI adoption.

The development of DSS for CDW management remains limited, with most DSS papers relying on formulas and indices rather than ML for CDW generation estimation. Therefore, there is a great need to integrate ML models, designed for predicting CDW generation and classifying and identifying CDW, with DSS. This integration can enhance decision-making on disposal options, optimal routes, and other crucial aspects.

While AI research is advancing rapidly, circularity in the construction industry is falling behind. AI has the potential to revolutionize CDW management, but its proactive and ethical adoption is crucial. Without careful consideration, the construction sector may struggle to effectively reduce waste generation and contribute to

decarbonization efforts. Future efforts should prioritize overcoming data availability issues, integrating ethical considerations such as model interpretability, and merging ML models with DSS and logistics to promote circular practices in construction.

ACKNOWLEDGEMENTS

This research project was financially supported by CAPES (Finance Code 001 - PhD scholarship for Carolina Lopes), CNPq (grants 408058/2023-4 and PQ Researcher for Júlia Mendes), and FAPEMIG (grant APQ-01838-21 for Julia Mendes). We are also grateful for the collaboration of the Research Group on Data Science in Engineering (CIDENG – CNPq). During the preparation of this work the authors used ChatGPT to check grammar issues and to improve readability. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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A REINFORCEMENT LEARNING FRAMEWORK FOR ECO-DESIGN IN WIRE ARC ADDITIVE MANUFACTURING USING DPG

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ABSTRACT

This work presents an eco-design framework tailored for Wire Arc Additive Manufacturing (WAAM) enhanced by Reinforcement Learning (RL). The main objective is to reduce production costs in terms of energy consumption, while ensuring compliant part without the presence of defects. To achieve this objective, the framework utilizes a Deterministic Policy Gradient (DPG) agent that interact with an environment made by a regression model and a binary classifier. This versatile framework can be applied to provide a decision-making support during the production of components based on various AM techniques.

Keywords: additive manufacturing; eco design; reinforcement learning; energy saving; sustainability

INTRODUCTION

Eco-design in Additive Manufacturing (AM) [1-2] integrates environmental considerations into the product design process to minimize environmental impact from creation to disposal focusing on material selection, recyclability, and optimizing energy efficiency through process parameter selection. In existing literature, design approaches for AM primarily concentrate on enhancing functional performance, manufacturability, and operational cost efficiency associated with the produced parts, e.g. obtained through a weight reduction using the topological optimization. [3-5] Consideration is also given to post-treatment processes required for additive manufacturing parts. In this field some works have been proposed. Cozzolino et al. conducted research on the power consumption of Ti6Al4V parts produced by Electron Beam Melting (EBM) and subsequently post-processed by milling [6] and turning [7]. Their study revealed optimal process parameters for achieving high-quality parts in terms of surface roughness while minimizing power consumption. Similar investigations were conducted by the same authors for Selective Laser Melting (SLM) process [8]. Furthermore, Napolitano et al. [9] investigated power consumption during the production of PLA parts using Fusion Deposition Modelling (FDM), analysing the influence of process parameters on both mechanical properties and energy consumption. Regarding metal part production via AM, it is recognized that powder-based processes exhibit lower sustainability compared to others. Among various AM technologies, Wire Arc Additive Manufacturing (WAAM) has gained attention due to its cost-effectiveness and rapid production capabilities [10]. In fact, Kokare et al. [11] demonstrated that WAAM process has a four times lower environmental impact compared to SLM. Despite this, the amount of research about this topic are still limited to few works. [12-13] As mentioned in this introduction, the primary focus revolves around conducting experiments on predefined parameters to determine the most optimal ones for minimizing production costs of a part. However, these optimization procedures are typically confined to the utilized process parameters, neglecting other potential combinations that could yield superior outcomes. Yet, artificial intelligence can be leveraged to pioneer advanced optimization techniques. This study introduces a comprehensive framework designed to aid decision-making during the setup of the WAAM fabrication process. Specifically, following an experimental campaign, regression models are employed to predict the power consumption associated with various combinations of process parameters. Additionally, a binary classifier is utilized to predict the presence

of defects in the process parameter combinations generated by an intelligent agent rooted in reinforcement learning.

MATERIALS AND METHODS

MODELLING ENERGY CONSUMPTION IN WIRE ARC ADDITIVE MANUFACTURING

WAAM process is an AM process based on principle of Gas Metal Arc Welding (GMAW). The process parameters which effect the energy consumption during the deposition process are the Welding Speed (WS), the Wire Feed Speed (WFS), the Welding Voltage (V) and the Contact to Workpiece Distance (CTWD). Nowadays, the selection of the process parameters is mostly related to the final desired outcome in the process in terms of layer geometry, but energy employed during the process should be considered according to eco-design. During an experimental campaign, 11 layers of 100 mm length of 1.2 mm Inconel 718 wire were deposited onto a stainless-steel substrate. The deposition process occurred under argon protection, with a fixed voltage automatically chosen from the synergic line developed by Lincoln. The parameters for the deposition, CTWD, WS and WFS, were selected from predefined sets: CTWD from {10, 15, 30}, WS from {600, 420}, and WFS from {6.5, 8.5} and all the combinations of them have been studied. The Power Average Indicator (PAI) is employed to assess power consumption. This index is determined as the average energy generated in the arc per millimetre, as depicted by Equation 1. Utilizing current and voltage sensors alongside a high-frequency acquisition system operating at 5kHz, the welding current and voltage have been measured throughout the deposition. Consequently, once the PAI is determinate a correlation with process parameters can be established using a linear regression.

$$PAI = \frac{1}{L} \cdot \frac{1}{N} \int_{t=0}^{t=N} I(t) \cdot V(t) dt \tag{1}$$

This relationship facilitates the estimation of the PAI for various combinations of process parameters, such as in efforts to minimize PAI within an eco-design framework. However, certain combinations of process parameters may result in defect generation, which must be prevented to reduce waste. Hence, the model employed during the optimization also incorporates a binary classifier for this purpose, allowing combinations that lead to defective parts to be discarded.

DETERMINISITC POLICY GRADIENT OPTIMIZATION

Reinforcement Learning (RL) maximizes long-term objectives through agent-environment interactions. Using the Policy Gradient Theorem (PGT) [14], neural network parameterized action policies guide the agent's actions, updated via gradient ascent to increase expected rewards. While traditional RL employs stochastic policies [15-16], Deterministic Policy Gradient (DPG) allows to directly map states to actions for optimization. The proposed framework consists into a linear regression and a binary classifier as the environment and a DPG algorithm which consist in a shallow neural network with 32 neurons for policy approximation. The reward function is the most important ingredient in RL. It should contain a gradient which helps agents gauge proximity to goals. The reward proposed for this task is a Gaussian-based function ensuring uniformity for distant states from the goal (minimum PAI) and a gradient near it, controlled by parameters β and η, reported in Equation 2.

$$r = \begin{cases} 0 & if \quad \lambda = 1 \\ \eta \cdot e^{\frac{-(PAI - PAI_{min})^2}{\beta}} & otherwise \end{cases} \tag{2}$$

When the binary classifier outputs is equal to 1, indicating the use of defective parameters, the reward is zero; otherwise, the objective is to minimize the PAI. Using OLS method to estimate the linear regression parameters, a Mean Absolute Error (MAE) of 2.8 is reached. The decision tree employed for anomaly detection possess an accuracy of 0.8. Although good results, the model accuracy can be improved using

more sophisticated techniques like neural networks for both regression and classification. The recommendations proposed by Mattera et al. [15-16] have been employed in formulating the network architecture for this particular context.

RESULTS

The agent has been trained using a learning rate of 0.0001 with Adam optimizer, a value of $\beta = 38$ representing the minimum value of PAI observed during the experimental campaign and $\eta = 15$. The optimal final set of parameters is 6.5 mm/min of WFS, 20 mm of CTWD and 600 mm/min of WS which lead to a final PAI of 50.8 W/mm with a reward of 0.6. Without any information about system dynamics the agent understands that it is better using the lower WFS due to lower welding current, increase the welding speed and using a higher CTWD at the limit between a good deposition. The results are summarized in Figure 1.

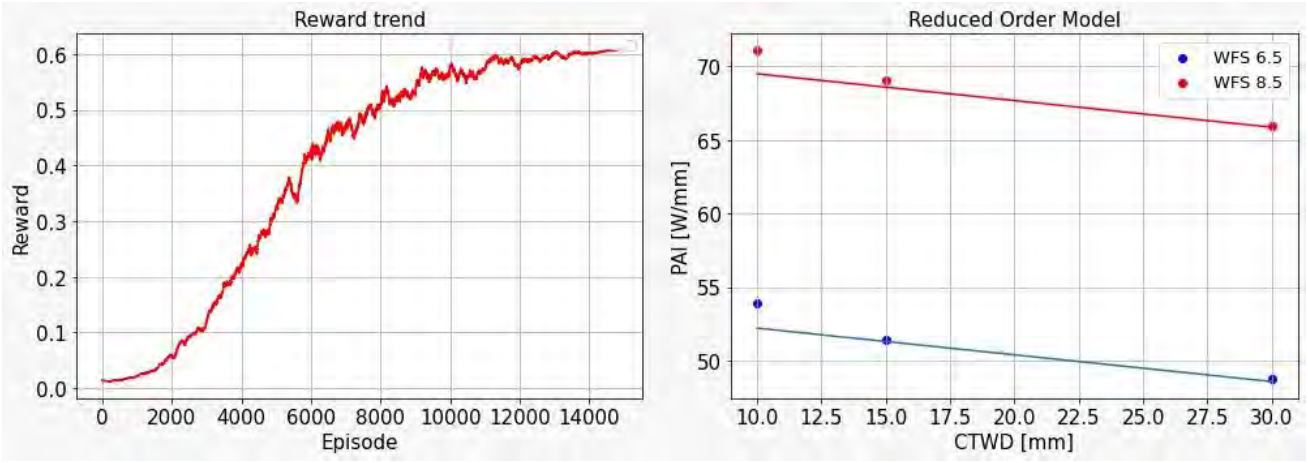

Figure 1 – Methodology outcomes: Linear regression predicts PAI accurately with low MAE. Reward function stabilizes optimally. Noisy behavior due to exploration phase with Gaussian noise in DPG output diminishes over episodes, enhancing system dynamics understanding.

CONCLUSIONS

This study introduces a comprehensive framework for optimizing process parameters in eco-design through RL. Leveraging data from an experimental campaign, we utilize a combination of a linear model and a decision tree anomaly detector as the environment. Interacting with a DPG algorithm, this setup facilitates the discovery of an optimal set of process parameters, ensuring the production of compliant components without defects while reducing power consumption for millimeter deposition. Future endeavors will extend this methodology to more extensive experimental campaigns and validate the results by synthesizing an optimal policy.

Acknowledgements: The INVITALIA Project on NEMESI and POR Campania FESR 2014/2020 Project TOP are gratefully acknowledged for their support to this research work.

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INFLUENCE OF THE PROPERTIES OF COATING MORTARS WITH INDUSTRIAL WASTES IN THE BUILDING'S THERMAL PERFORMANCE

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ABSTRACT

In recent years, industrial wastes such as steel slag, friable quartzite, and iron ore tailings have shown promise as substitutes for natural sand, offering both mechanical and thermal advantages. These materials can be used to produce coating mortars, improving the thermal performance of building envelopes. Given the importance of energy efficiency in construction, this study examined how varying the thickness of waste-based coating mortars affects thermal performance. Energy simulations revealed that adjusting mortar thickness can significantly impact the building's thermal performance, up to 733.4 kWh in annual energy demand. The findings demonstrate that using these waste materials and optimizing coating thickness can enhance envelope thermal performance, leading to energy savings of up to R$216.89 or US$43.64 compared to conventional mortar. In conclusion, integrating these waste materials not only benefits energy conservation and reduces financial burden on households, but also minimizes reliance on natural resources and mitigates the impacts of waste disposal.

Keywords: Sustainable mortar; Reuse of solid waste; Thermal performance; Energy efficiency; Coating mortar.

INTRODUCTION

Given the high environmental impacts of the construction industry, there has been a growing interest in exploring sustainable alternatives for construction materials [1]. Different industrial wastes, such as Steelmaking Slag (SS), Friable Quartzite (FQ), and Iron Ore Tailings (IOT), are being studied as partial or total substitutes for natural fine aggregate in coating mortars. These wastes, usually generated in high volumes, are often inadequately disposed of, leading to serious consequences [2, 3]. Still, when applied in coating mortars, they have shown promising mechanical and physical performance [4, 5, 6], as well as enhanced thermal properties in some cases [6].

The building's envelope isolates the internal environment from the external one, and the thermophysical properties of its construction materials play a crucial role in the building's thermal performance [7]. The thermal performance, in turn, is directly related to the building's energy efficiency [7]. There are already studies showing the feasibility of implementing coating mortars produced with residues to improve the building's thermal performance [6, 8]. However, no article was found investigating the effect of variations in the quantity of coating mortars on the thermal performance of the building, exploring the full potential of these mortars. The present work aims to evaluate the impact of the thickness of waste-based coating mortars on the thermal performance of buildings, aiming to increase their energy efficiency. Thus, this project contributes to UN's SDGs 9 (Industry, innovation, and infrastructure) and 11 (Sustainable cities and communities).

MATERIALS AND METHODS

To reach our goal, we conducted energy simulations of a small-scale dwelling, with its walls coated with 3 types of waste-based mortar. The thickness of these mortars was ranged from 1cm to 3cm (in steps of 0.5cm). The simulations were carried out using EnergyPlus (v9.6); considering one entire reference year for 3 Brazilian cities: São Joaquim (one of the coldest cities in the country), Corumbá (hot climate), and São Paulo (mild climate) [9].

The building comprises a 40m²-single-family dwelling (Figure 1). The wall system consists of ceramic blocks laid with conventional laying mortar, coated on both sides with the studied mortars, and painted with common paint, as seen in Figure 1. We also simulated the envelope with a 20-mm-conventional mortar, for comparison. For the modeling in EnergyPlus, we adopted the mortar's thermophysical properties presented in Table 1 [9].

The properties of the mortars are the result of a previous study [6]. According to the selected thicknesses, the thermal transmittance of the wall system varied between 2.07W/(m²·K) and 2.61W/(m²·K); and its thermal capacity between 64.73kJ/(m²·K) and 143.98kJ/(m²·K) (Table 2). We used the standard software properties for other materials (e.g., wood and glass). We set the building's occupancy pattern, lighting, and setpoint temperatures (21-23°C) according to the Brazilian standard NBR 15575 [10]. The building's thermal performance analysis was based on the thermal load method – evaluating the energy demands to heat and cool the long-term occupancy spaces (living room and bedrooms) [10, 11].

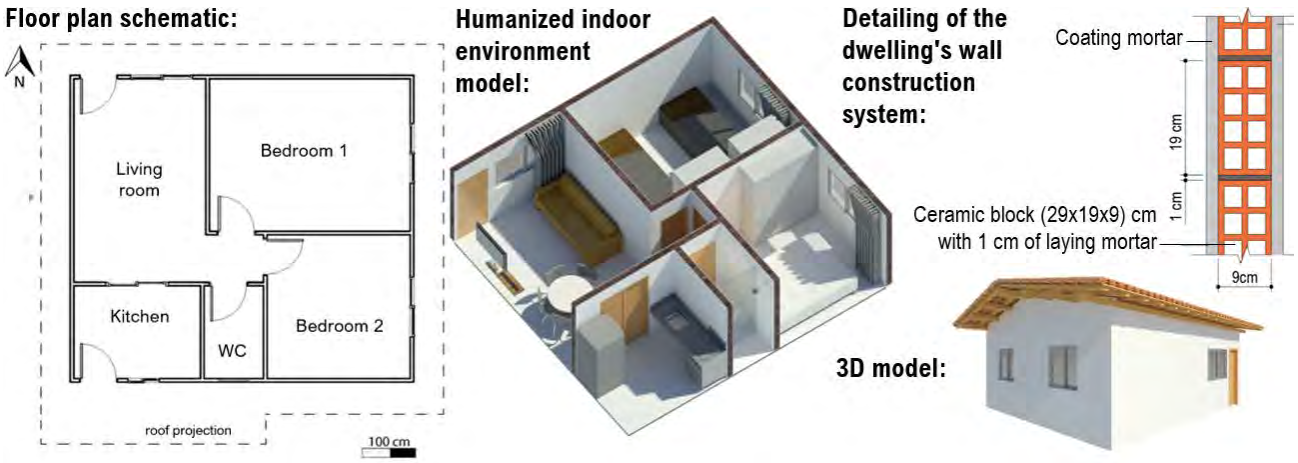

Figure 1: Detailing of the simulated dwelling.

Table 1: Thermal properties of the construction materials

	SS mortar	FQ mortar	IOT mortar	Reference mortar (REF)	Block + laying mortar
Thermal conductivity	0.72 W/(m·K)	0.94 W/(m·K)	0.49 W/(m·K)	1.15 W/(m·K)	0.47 W/(m·K)
Specific heat	0.72 kJ/(kg·K)	0.75 kJ/(kg·K)	0.75 kJ/(kg·K)	1.00 kJ/(kg·K)	0.93 kJ/(kg·K)
Specific gravity	2442.00 kg/m³	1754.00 kg/m³	1821.00 kg/m³	1950.00 kg/m³	459.82 kg/m³

Table 2: Wall's thermal transmittance (U) and thermal capacity (Ct) according to thickness and type of the mortar.

	Wall with SS mortar					Wall with FQ mortar					Wall with IOT mortar					REF
Thickness (m)	0.010	0.015	0.020	0.020	0.030	0.010	0.015	0.020	0.025	0.030	0.010	0.015	0.020	0.025	0.030	0.020
U (W/(m²·K))	2.57	2.48	2.40	2.52	2.25	2.61	2.54	2.47	2.41	2.35	2.49	2.37	2.26	2.16	2.07	2.52
Ct (kJ/(m²·K))	73.65	91.23	108.82	116.49	143.98	64.73	77.85	90.97	104.09	117.21	65.91	79.62	93.34	107.05	120.76	116.49

RESULTS

Figure 2 shows the thermal load (energy demand) required for cooling/heating the internal environment. The higher the mortar's thermal performance, the lower the thermal load will be. Among the evaluated cities, São Paulo is the city that provides the lowest energy demand, which is expected, given that mild climates tend to provide a more comfortable environment throughout the year [12]. In the extreme cities, Corumbá (hot climate) and São

Joaquim (cold climate), the IOT mortar ensured the lowest energy demand, combined with similar result to the SS mortar in São Paulo, providing to be the best alternative to promote building's performance for the case study. FQ mortars obtained relatively high energy consumptions in most cases, i.e., the lowest thermal performance. Furthermore, in São Paulo and São Joaquim, REF mortars obtained better results than FQ with the same thickness.

Regarding the variation in thickness, in general, reducing the thickness was favorable for improving the building's thermal performance in Corumbá (hot climate). Mortars with reduced thickness increase the envelope's thermal transmittance (thus the rate of heat transfer between outdoors and indoors) and decrease its thermal capacity (its ability to retain/store heat) (Table 2). An envelope with low thermal capacity leads to higher indoor thermal fluctuations and a high thermal transmittance increases susceptibility to the external climate [9].

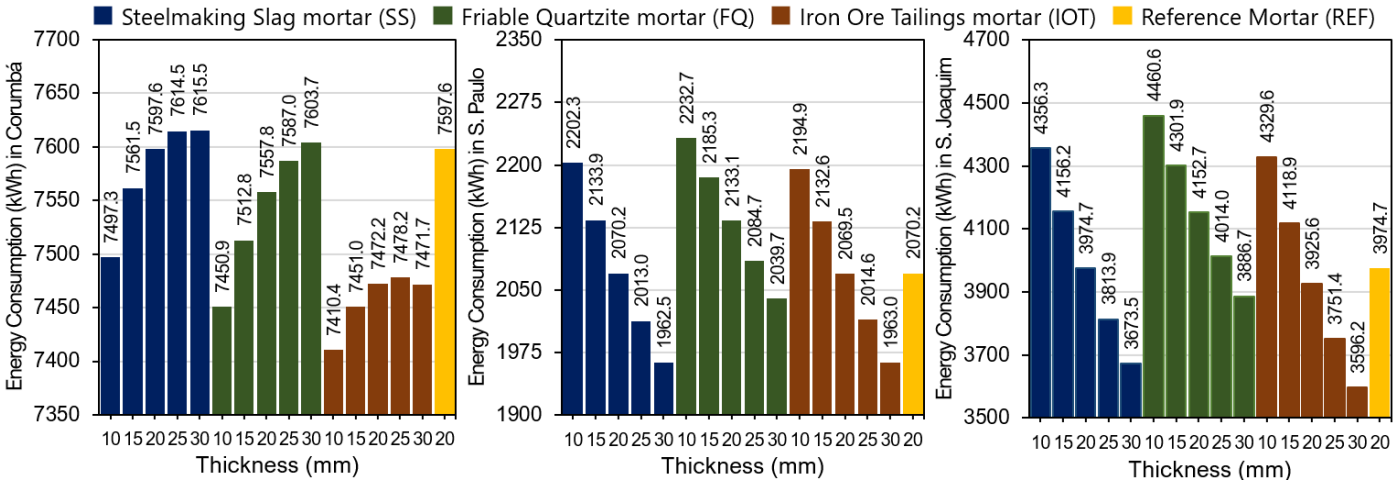

Figure 2: Dwelling's energy consumption with mortar variations in Corumbá (hot climate), São Paulo (mild climate) and São Joaquim (cold climate).

At first glance, reducing the mortar's thickness seems like an inadequate measure to improve the building's thermal performance. However, in Corumbá, due to the region's high temperatures and the dwelling's design, larger thicknesses promoted overheating, given that the heat was "stored" in the mortars with high thermal capacity, and "trapped" inside due to their low heat transfer rate. Hence, in this hot region, envelope materials that facilitate heat exchange provided an energy-saving opportunity by reducing the cooling demand. In Corumbá, the change in FQ's thickness obtained the highest variation in energy consumption,152.8 kWh. The 10-mm-IOT mortars, with the best performance, reduced the energy consumption in 187.2 kWh in relation to the 20-mm-REF (R$164.69 or US$33.14 on the local energy bill [13]; US$1.00 = R$4.97 in 28/02/2024).

In São Joaquim (cold city), we noticed that increasing the mortar's thickness ensures better thermal performance. As mentioned, a greater thickness results in lower thermal transmittance and higher thermal capacity for the envelope. In this city, the envelope's reduced heat flow decreased the heat loss from the internal environment; and its high thermal capacity prevented abrupt changes in the internal temperature (set for comfort). In São Joaquim, once again the IOT mortar ensured better thermal performance. The best result, 30mm, promoted an annual energy saving of 378.5 kWh (R$216.89 or US$43.64) in comparison to the REF [13]. The IOT mortar also obtained the highest variation in thermal performance according to its thickness, 733.4 kWh.

In São Paulo (mild climate), moderate behaviors were observed. The SS mortar (worst in the hot city) and IOT mortar (best in both cities) demonstrated almost similar thermal performance, considering the thickness range analyzed. These were the mortars that promoted the best thermal performance for the dwelling in this city. The best mortar, 30-mm-SS-mortar could potentially save 107.7 kWh or R$70.63 or US$14.21 in relation to the REF [13]. The highest variation according to the mortar thickness was IOT (239.8 kWh), 57% higher than in Corumbá and 67% smaller than São Joaquim. These results show that the effect of variating the mortars' thickness is more notable in colder cities.

CONCLUSIONS

This study evaluated the thermal performance of a small-scale building with variations in the thickness of mortars made with industrial wastes. The mortar that promoted the greatest variation in thermal performance when altering its thickness was the IOT in hot weather, with 733.4 kWh. The impact of the mortar coatings on the building's thermal performance varied among the different tested climates. Therefore, it is essential to consider the specific thermophysical properties of the construction materials when selecting the envelope materials. The findings indicate that waste-based coating mortars have the potential to yield savings of up to R$216.89 or US$43.64 on annual energy bills, thereby enhancing the building's energy efficiency. In summary, these wastes have several benefits to the construction sector, potentially reducing energy consumption, energy bills, the demand for natural resources and the impacts of waste disposal. In conclusion, the appropriate selection of coating mortars and their construction parameters (thickness) can have a significant impact on the thermal performance of buildings in Brazil and other countries with similar climates.

ACKNOWLEDGEDMENTS

We would like to thank CAPES (Coordination for the Improvement of Higher Education Personnel; Financing Code 001 – PhD scholarship for Aldo Carvalho, Júlia Assumpção and Vítor Mendes) and CNPq (National Council for Scientific and Technological Development; grants 408058/2023-4 and 305818/2023-6 - PQ researcher for Júlia Mendes).

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USING MACHINE LEARNING TO PREDICT THE THERMAL PERFORMANCE OF BUILDINGS AND SELECT CONSTRUCTION MATERIALS

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ABSTRACT

The increase in energy demand for indoor conditioning over the years has led to a rise in greenhouse gas emissions worldwide. Prioritizing a building's thermal performance leads to high energy efficiency, which is crucial for ensuring comfort for the users with minimal energy usage. The present study employed machine learning (ML) models, including Recurrent Neural Networks (RNN) and Decision Tree Regression (XGBoost), to predict a building's thermal performance, varying the construction materials of its envelope. The models were trained using energy simulations (EnergyPlus software) conducted in São Paulo, Brazil, for two thermal performance methods: Thermal Load (TL) and Degree-Hour (DH). Both ML models demonstrated high effectiveness in performance prediction (R^2>0.98), with XGBoost presenting the best results. This study thus evidences the promising role of ML in guiding the selection of appropriate building systems and saving energy.

Keywords: Thermal performance; Machine learning; XGBoost; RNN; Energy simulation.

INTRODUCTION

Buildings make a significant contribution to global energy consumption and, consequently, an increase in greenhouse gas emissions and global warming [1]. A building envelope with suitable thermal performance promotes the well-being of its occupants, while contributing to energy savings for indoor conditioning [2]. The thermal performance of a building is influenced by its floor plan, height, shadowing, solar orientation, ventilation, among others, with the envelope materials being one of the highest contributors [48]. Building standards throughout the world outline procedures for analyzing the thermal performance, usually through energy simulations.

The main methods for evaluating the thermal performance of a building are Degree-Hours (DH) and Thermal Load (TL) [49]. The DH method compares indoor temperatures with thermal comfort setpoint temperatures, evaluating the degree-hours of the occupant's discomfort [49]. In turn, the TL method measures the amount of energy consumed by a HVAC equipment to maintain the indoor temperature within a comfort temperature range [49]. In both cases, the lower the DH or the TL, the best will be the thermal performance of the envelope system, since it was able to maintain the internal temperature within the comfort ranges for the most part of the year.

However, conducting energy simulations demands substantial human and computational resources [5]. Thus, machine learning (ML) has emerged in recent years as a promising alternative because it can process large volumes of data, identify patterns, and make decisions [6]. The use of ML to predict thermal performance represents an efficient alternative, as it provides satisfactory results in significantly reduced time [7]. In this context, this work aims develop an efficient ML model to predict the thermal performance of a building (considering TL and DH methods), aiming to contribute to the selection of construction systems. The novelty of this work is the performance of a case study in a low-income house in São Paulo, Brazil; using typical Brazilian construction systems. This project contributes to UN's SDGs 9 (Industry, innovation, and infrastructure) and 11 (Sustainable cities and communities).

MATERIALS AND METHODS

We conducted energy simulations in EnergyPlus (v22.1.0) to examine the thermal performance of a 43m²-single-family residence (Figure 01). We evaluated 10 distinct construction systems for the wall, floor, and roof (1000 combinations in total). For the wall system, we varied the type and thickness of the masonry blocks and coating mortars, resulting in thermal capacity between 55.6-334.7 kJ/(m²·K), and thermal transmittance (U-values) between 2.5-7.2 W/(m²·K). Regarding the floor, the surface and underlying layers were varied. Then, the thermal capacity of the floor systems ranged between 58.5-437.2 kJ/(m²·K), and the U-values, between 1.9-14.1 W/(m²·K). Finally, concerning the roof, we varied the presence of lining, slab, tile, and thermal insulation blanket, obtaining thermal capacity between 99.9-666.0 kJ/(m²·K), and U-values between 1.2-3.2 W/(m²·K). The list of materials for each construction system and their thermophysical properties considered in the simulations are available at https://github.com/cidengcnpq/machine-learning-model-for-thermal-performance-/blob/main/dataset/materials.xlsx. We configured the occupancy pattern, lighting, and operative temperature according to standard NBR 15575 [53].

Figure 7 – Simulated residence. Left: external 3D model. Middle: internal 3D model. Right: floor plan.

For the analysis, we chose the city of São Paulo, classified as "Csa" in Köppen-Geiger classification, i.e., humid subtropical climate. The analysis for TL was focused on long-term environments (living room and bedrooms), simulated over a reference climatic year, with the HVAC's operating in certain hours according to the standardized occupancy pattern. DH results were continuously extracted throughout the year, 24/7, focusing on the living room due to its critical behavior among the long-term rooms. After simulating each set of walls, floors, and roofs, the thermal performance results were compiled and used to train the ML models.

For the ML models, we used the Decision Tree Regression (XGBoost) technique from XGBoost library, and Recurrent Neural Networks (RNN) technique from scikit-learn library. In the case of XGBoost, hyperparameters were fine-tuned using the RandomizedSearchCV technique with the following values: coolsample_bytree = 0.44087; learning_rate = 0.4521; max_depth = 8; min_child_weight = 3.6962; subsample = 0.7060. Conversely, for RNN, hyperparameters were manually adjusted: hidden_layer_sizes = (575, 100, 50); activation function: 'relu'; optimizer: 'adam'; epochs = 2000; random_state = 42.

Developed in Python, the ML model handled input and output variables, utilizing the libraries provided by Google's Colab Virtual Machine (VM), following the parameters outlined by Paixão et al. [9]. The properties of each set of materials (thermal capacity and thermal transmittance) of each system (walls, floors, and roof) were used as input, and the thermal performance (TL or DH) was the predicted output. We not only compared the ML models among themselves, but also assessed if the prediction accuracy for TL and DH would be different. We adopted cross-validation (10-fold) as the training/testing procedure, i.e., the models were trained 10 times, using a tenth of dataset as test and the rest as training each time. We used the coefficient of determination (R^2), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE) metrics to evaluate the model's accuracy in predicting thermal performance results based on the thermophysical properties of walls, floors, and roofs.

RESULTS

Table 1 shows the model accuracy for both scenarios. No significant differences were observed when predicting the TL in comparison with DH, because they have similar evaluation mechanics [49].

Table 5 – Accuracy of the evaluated ML models, XGBoost and RNN.

	Prediction of thermal load (TL)			Prediction of degree-hours (DH)		
	R^2	MAE (J)	MAPE (%)	R^2	MAE (degree-hour)	MAPE (%)
XGBoost	0.9989	7.9692	0.0013	0.9980	18.0402	0.0070
RNN	0.9874	34.4239	0.0055	0.9930	40.2383	0.0158

XGBoost exhibited superior quality metrics, boasting an R^2 of 0.9989 for predicting TL and 0.9980 for predicting DH. Notably, XGBoost demonstrated significantly lower MAPE metrics compared to the RNN model: over fourfold reduction for TL simulation and twofold reduction for DH simulation. This performance of XGBoost can be attributed to the inherent capability of decision trees to generalize well with relatively less data. Additionally, the algorithm's adeptness in handling high-dimensional attribute spaces contributes to its superior performance over RNN. Furthermore, the findings of this study are consistent with prior research by Wang et al.[11], which also reported satisfactory outcomes in predicting heating loads using XGBoost. Despite XGBoost yielding the most favorable results, both methodologies achieved MAPE values below 0.1%, underscoring their remarkable efficacy. These findings underscore the promise of ML models as robust strategies for accurately predicting heating and cooling loads, or heating and cooling degree-hours, by effectively correlating the properties of construction materials with a building's thermal performance.

Additionally, simulating one case in EnergyPlus averaged 16.5 seconds on a computer with an Intel Core i5 processor and 16 GB of RAM. However, on average, the XGBoost model required just 0.59 seconds, and the RNN model took only 28.44 seconds to train, cross-validate, and compute the metrics for 1000 cases using the Colab VM, which does not depend on specific computer capacities. After being trained, the ML models can predict an infinite number of other cases in a fraction of the time required for energy simulations, allowing for comprehensive exploration of different strategies for improving thermal performance. This result shows how ML models are efficient as well as accurate in predicting thermal performance.

XGBoost boasts an additional advantage attributable to its calculation methodology, as this technique can elucidate the degree of importance associated with each input variable in predicting the output. Across both scenarios, the input variable exerting the most substantial influence on the outcome was identified as the thermal capacity of the walls, with coefficients of 0.687 for the TL method and 0.639 for the DH method, as depicted in Figure 2. Conversely, the thermal capacity of the floor emerged as the least influential input, with coefficients of 0.002 for the TL method and 0.006 for the DH method. These findings partially corroborate those of Mendes et al. [48], who observed that the thermal capacity of coating mortars wielded greater influence on a building's thermal performance than their thermal transmittance. Despite the current study's limited scope focusing solely on a small dwelling, these findings suggest that designers should prioritize efforts towards enhancing the thermal capacity of walls to improve a building's thermal performance, relative to other properties and systems. Further investigations are warranted to validate this insight across diverse building typologies.

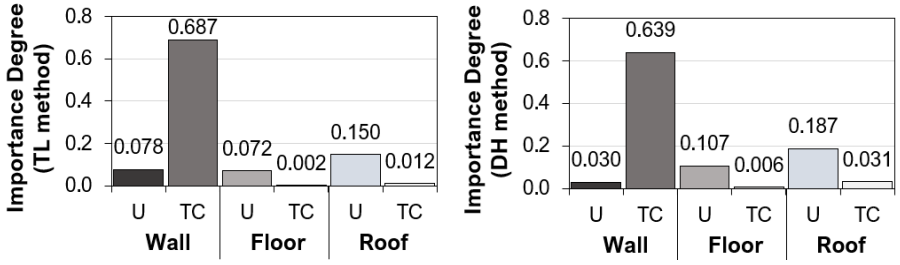

Figure 8 – Importance Degree of variables in XGBoost predictions for TL and DH methods.
Note: U = thermal transmittance; TC = thermal capacity

CONCLUSIONS

Through energy simulations and ML techniques, the present work succeeded in developing a model capable of predicting the building's thermal performance from its envelope materials, contributing to the selection of suitable construction systems. Although the case study was carried out in the Brazilian context, the strategy developed here can be extrapolated to other regions and buildings. Both ML techniques tested, XGBoost and RNN, reached suitable results, but XGBoost was the faster and more accurate one ($R^2 > 0.998$). The models presented similar performance when predicting the TL and the DH. Additionally, the thermal capacity of the walls was the more important property for improving the building's thermal performance, while the floor thermal transmittance was found to be least significant. However, one should notice that the results of this study are limited to the investigated simulated residence, construction materials and climate. More studies are suggested to verify if these findings are applicable to different conditions. In conclusion, this work reinforces the potential of ML techniques as efficient and effective tools to predict building's thermal performance. This enables designers to select the best materials for a building with speed and accuracy, thus contributing to the well-being of the building's occupants and energy savings.

ACKNOWLEDGEDMENTS

We would like to thank CAPES (finance 001 – master's scholarship for Gabriela Oliveira and PhD scholarship for Vitor Mendes), CNPq (junior research scholarship for Israel Louback in collaboration with PROPP/UFJF; grants 408058/2023-4 and grant 305818/2023-6 - PQ researcher - for Julia Mendes), and FAPEMIG (grant APQ-01838-21). We are also grateful for the collaboration of the Research Group on Data Science in Engineering (CIDENG – CNPq). During the preparation of this work, the authors used ChatGPT to check for grammar issues and improve readability. After using this tool, the authors reviewed and edited the content as necessary and assume full responsibility for the publication's content.

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UTILIZATION OF CASSAVA BAGASSE FOR CITRIC ACID PRODUCTION THROUGH FERMENTATION

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ABSTRACT

In this research, cassava bagasse, an agro-industrial waste from the tapioca industry, was used as raw materials for citric acid production. Different fermentation methods, namely submerged and solid state fermentation were performed, along with variation of cassava bagasse particle sizes to assess their impact on citric acid production. Spectrophotometric analysis revealed that the smallest particle size (60 mesh powder) resulted in greater citric acid levels compared to other particle size variations across both fermentation methods tested. Furthermore, solid state fermentation method resulted in higher citric acid formation in a shorter timeframe compared to submerged fermentation method. The result obtained in this research showed the potential of cassava bagasse as citric acid raw materials through solid state fermentation.

Keywords: cassava bagasse, citric acid, fermentation.

INTRODUCTION

Agro-industrial waste is defined as waste generated from agricultural processing industries. Its abundant availability provides the potential for repurposing them as raw materials for other industrial process. Agro-industrial waste typically rich in sugar or carbon sources, minerals, protein, and moisture, which makes them ideal for utilization as fermentation substrate [1], [2]. The utilization of agro-industrial waste for fermentation substrate has gained interest, yielding products ranging from bulk chemicals to value added fine products, such as ethanol, enzymes, amino acids, and organic acids. This strategy will help contributing to waste reduction efforts [2], [3].

Among different product that can be produced through fermentation, citric acid is especially interesting due to its wide applications across various industries, including food, cosmetics, pharmacy, beverages, and many others [4], [5]. Currently, citric acid is the top acidulants used in food industries, due to its pleasant taste and flavor-enhancing properties. Traditionally, citric acid production relies on submerged fermentation (SmF) using the fungus *Aspergillus niger*, a method that requires considerable energy and water usage [6]. Recent research has focused on the use of solid state fermentation (SSF) instead, a method that can be operated using minimal amount of water, thus significantly reducing operating cost and energy requirement. Importantly, solid state fermentation allows the direct utilization of agro-industrial waste without the need for pretreatment [7].

Numerous types of agro-industrial waste have been reported for citric aicd fermentation, such as sugar cane bagasse or coffee husk [8], empty oil palm fruit bunches [9], and orange peel [10]. One of the locally available agro-industrial waste that can be utilized is cassava bagasse, which is formed as a by-product of tapioca flour production. This waste is especially suitable as raw substrate in fermentation process because of its low ash content, ranging from 0.66 – 1.50 g/100 g dry weight of bagasse, thus facilitating microbial bioconversion process quite well [3]. However, due to variations in size and shape, further study is necessary to enhance fermentation efficiency [2].

This study explores the potential of cassava bagasse as raw materials for citric acid production through fermentation. The effect of solid substrate size from the locally available cassava bagasse were assessed on both SmF and SSF processes.

MATERIALS AND METHODS

CITRIC ACID FERMENTATION

Cassava bagasse was obtained from a tapioca factory in Bogor, Indonesia. The bagasse was dried in an oven at 80°C, followed by slicing and/or grinding with a food chopper to obtain bagasse with different size (2-3 cm slices, coarse powder, and 60 mesh powder). Subsequently, 5 grams of the prepared bagasse were placed into individual 250 mL Erlenmeyer flask and sterilized.

Aspergillus niger ITBCC L74 (obtained from Laboratory of Microbiology and Bioprocess Technology, Department of Chemical Engineering ITB) was cultivated on slanted potato dextrose agar (PDA) at room temperature and was regenerated every month. Dry spore suspension of *A. niger* was prepared by adding 5 mL of sterile aqua dm to each slanted agar containing 5-days old *A. niger* culture, The resulting suspension was then transferred to sterile rice media in perforated baking dishes and incubated at 37°C for 7 days. The cultured dry rice was ground into powder. 0.25 gr of culture powder was then added into each Erlenmeyer flask prior to fermentation, along with the liquid fermentation medium. The composition of the fermentation medium consisted of 100 g/L glucose, 0.261 g/L KH_2PO_4, 0.3 g/L $MgSO_4.7H_2O$, 1.14 g/L NH_4NO_3, 0.1 mg/L $FeSO_4.7H_2O$, and 0.25 mg/L $ZnSO_4.7H_2O$ [11].

Two different fermentation methods were employed, namely SmF and SSF. For SmF, 100 mL of sterile liquid medium was added to each flask, followed by incubation at 37°C, 140 rpm. Conversely, for SSF, only 8 mL of sterile liquid medium was added to each flask, followed by incubation at 37°C without agitation. All fermentation were carried out for 7 days.

CITRIC ACID ANALYSIS

Analysis of citric acid were performed using spectrophotometric analysis method [12]. For SSF, around 100 mL of aqua dm was added into the flask, mixed, and filtered to separate the extract (containing citric acid) from the solid, then 0.5 mL of aliquots were collected for analysis. For SmF, 0.5 mL of liquid medium were used for analysis. The samples were mixed with 0.65 mL of pyridine reagent and 2.85 mL of acetic anhydrous reagent, followed by incubation for 30 minutes to let colour formation. The absorbance was measured using UV-Vis spectrophotometer at 420 nm.

RESULTS AND DISCUSSION

Experimental results show that the smallest substrate size (60 mesh powder) yielded the highest citric acid production, both in SmF and SSF. The maximum citric acid yield in SSF was achieved after 5 days of fermentation, reaching 67.93 mg/gr substrate. Substrate size can affect citric acid production, as smaller substrate can enhance mass and heat transfer and providing increased surface area for the fungus *A. niger* to carry out the citric acid bioconversion process [13]. This phenomenon was also demonstrated in SSF using carob pod substrates [14], sugarcane bagasse [15], and empty oil palm fruit bunches [9]. It was also reported that the effect of substrate size reduction on citric acid yield was only effective up until the substrate reached a certain optimal size.

In SmF, the maximum citric acid yield was obtained when 60 mesh powder was used as the substrate, reaching 24.45 mg/gr substrate after 6 days of fermentation. Substrate particle size indirectly influences fungal growth rate, which is one of the main factors influencing citric acid productivity [16]. Finer substrates offer larger surface area for fungal access, thus promoting its growth into pellets which are preferred in SmF.

Comparison between the 2 different fermentation methods showed that SSF was able to achieve 2.8 times greater citric acid yield and in shorter fermentation time compared to SmF. The condition that was used in SSF closely mimic the natural growth condition of the fungus *A. niger*, facilitating enhanced metabolic activity to form citric acid and encouraging the release of more hydrolytic enzymes to hydrolyze the substrate [10], [11]. Additionally, SSF condition support better oxygen transfer rate, allowing faster *A. niger* growth and consequently, higher citric acid yield [11].

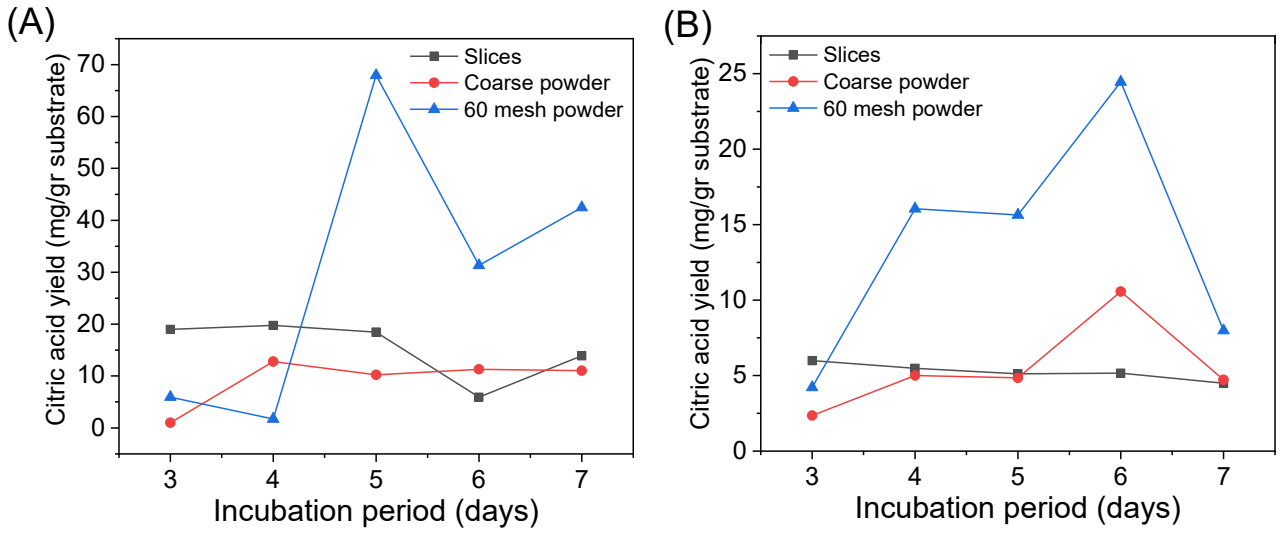

Figure 9 – Citric acid yield at different incubation period and substrate size in (A) SSF and (B) SmF process.

CONCLUSIONS

Citric acid fermentation from cassava bagasse was carried out using both SSF and SmF methods. The use of finer substrate (60 mesh powder) led to higher citric acid yield compared to larger substrate size, irrespective of the fermentation method used. Notably, SSF method yielded significantly greater citric acid production compared to SmF. This study showed the distinct advantage of SSF, particularly its capacity to effectively utilize agro-industrial waste while minimizing water and energy consumption. This highlights the potential of SSF as a sustainable and efficient approach for citric acid production from renewable resources such as cassava bagasse.

ACKNOWLEDGEDMENTS

The authors used ChatGPT in order to check grammar issues and to improve readability. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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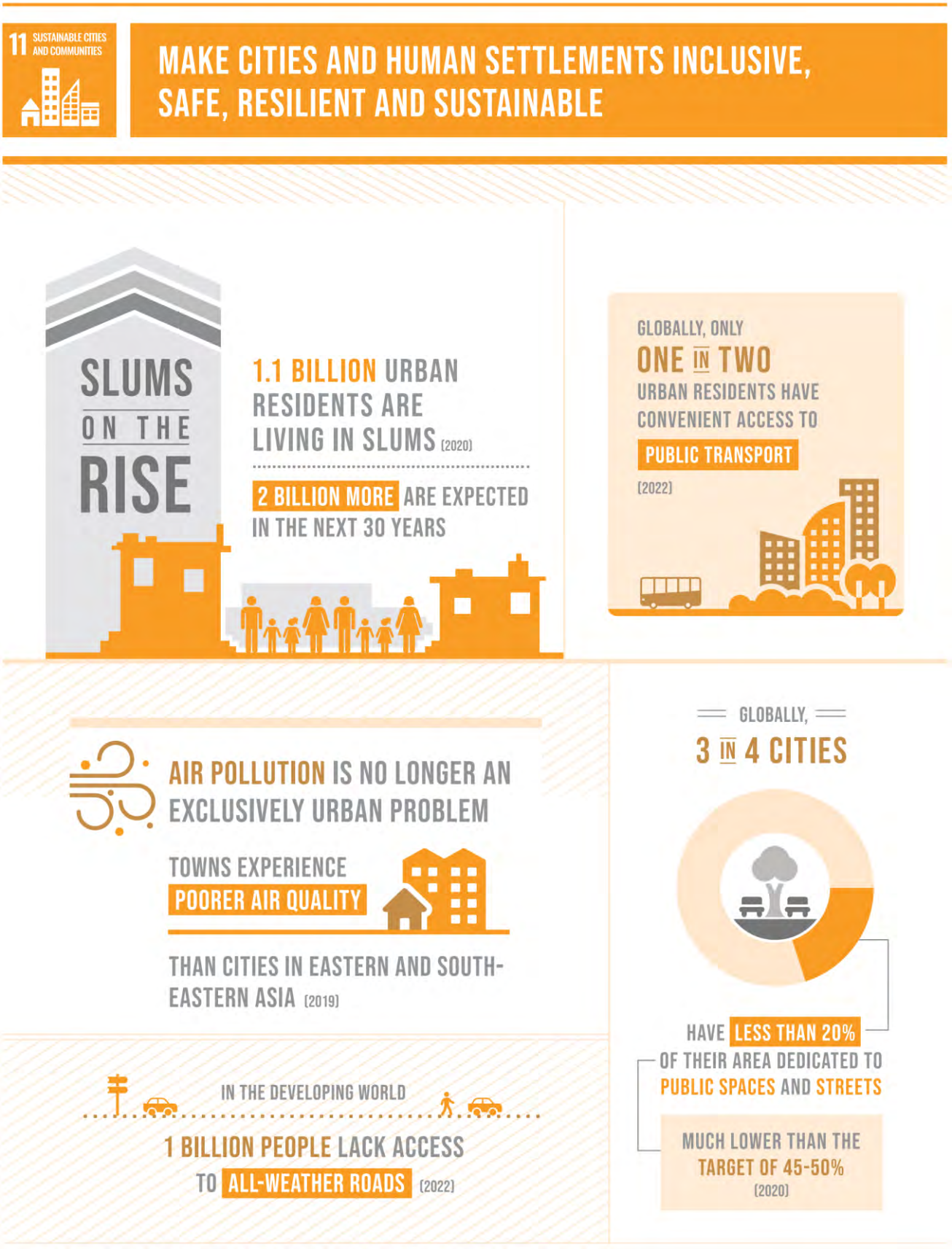
GOAL 11: MAKE CITIES AND HUMAN SETTLEMENTS INCLUSIVE, SAFE, RESILIENT AND SUSTAINABLE



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EXPLORING THE POTENTIAL OF INTEGRATING BIOPHILIC DESIGN APPROACH FOR SUSTAINABLE LANDSCAPE PRACTICES: A GEOMORPHOLOGICAL STUDY OF BARCHAN DUNE

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ABSTRACT

Man has always been captivated by the alluring beauty of natural landscapes since the dawn of time, sometimes unable to fully comprehend the phenomena behind their existence. Long before man set foot on the planet, nature has been at play shaping our environment and creating intricate wonders. Given nature's ability to create resilient landscapes that adapt to the ever-changing dynamics of the ecosystems, it becomes prudent to learn from the natural processes to develop solutions to address contemporary environmental concerns and challenges faced by man today. With the philosophy behind Biophilic design that tends to create a harmonious coexistence between man and his natural environment, this research aims to investigate the potential of integrating Biophilic design approach for sustainable landscape practices with a specific focus on the geomorphological aspect of Barchan Dune as a new approach. The research employed a multi-faceted methodology, utilizing both qualitative and quantitative approaches. On-site observations, case study documentation, and interviews with interdisciplinary experts were used to gather qualitative data. Meanwhile, environmental data were analyzed using remote sensing and geographical information systems, of bio-inspired algorithms which were implemented with the aid of Matrix Laboratory and Python for optimization and pattern generation. The findings revealed that fluctuations in climate conditions influenced the morphology of Barchan Dunes, resulting in distinct patterns in the dunes' shapes, orientations, and sizes. This clarified a correlation between environmental factors and dune morphology, facilitating a comprehensive understanding of its effective potential for integration into practices across various fields.

Keywords: Potential; Biophilic design; Sustainable Landscape; Geomorphological study; Barchan Dune.

INTRODUCTION

Biomimicry serves as a portal for unlimited design inspiration from nature, it is an approach to unleash innovative possibilities for pioneering nature-based design solutions. The term is derived from two ancient Greek words: bios (βίος), which means life, and mīmēsis (μίμησις) or mīmeisthai (μιμε σθαι), which means imitation or to imitate [1]. Hence, Biomimicry is a scientific approach that takes inspiration from nature's forms, processes, and ecosystems to create more sustainable designs.

Biophilic design can incorporate nature into our environment and design places of inspiration and regeneration that bind humans to their environment. A “love of life or living systems” is biophilia (Aristotle) its origin was first introduced in the book ‘Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life [2]. According to the book, there are two basic dimensions of biophilic design; the first dimension is the organic or naturalistic dimension, which represents the shapes and forms. Secondly, the basic dimension of the place-based or vernacular dimension represents the buildings and landscapes connected to the culture and ecology of the local environment [3]. Biophilic design patterns were defined to guide and assist in the design process and the main purpose was to explain the connection between the characteristics of built and natural environments [4] hence this research tends to explore the potential of integrating biophilic design approach in landscape architecture. The study will focus on the geomorphological formation of the barchan dune. A dune is a landform formed from a phenomenon of wind- or water-driven

sand. It typically takes the form of a mound, ridge, or hill [5]. Such landforms are most commonly found in desert environments, where the lack of moisture hinders the growth of vegetation that would otherwise interfere with the development of dunes. It occurs in different shapes and sizes, but most kinds of dunes are longer on the stoss (up-flow) side, where the sand is pushed up the dune, and have a shorter slip face on the lee side. A common example of it is a crescent-shaped dune otherwise known as Barchan Dune. Barchan Dunes tend to face the wind, appearing convex, and are produced by wind action predominantly from one direction. They are a very common landform in sandy desert regions across the world and are arc-shaped, markedly asymmetrical in cross-section, with a gentle slope facing toward the wind sand ridge, comprising well-sorted sand. This type of dune possesses two "horns" that face downwind, with the steeper slope known as the slip face, facing away from the wind, downwind, at the angle of repose of 7 the sand in question, approximately 30–35 degrees for medium-fine dry sand [6], [7].

The research aims to investigate the potential of integrating a Biophilic design approach for sustainable landscape practices with a specific focus on the geomorphological aspect of Barchan Dune. The research will provide insights towards a deeper understanding of how the feasibility can be gained regarding the effective potential of integrating Biophilic design approach for sustainable landscape practices.

The aim of this research will be achieved through the following objectives:

- To examine the geomorphological formation of barchan dunes
- To identify the biophilic design potentials from barchan dunes geomorphology and to analyze its effective potential of integration into sustainable landscape practices
- To recommend how the research could inform future developments and advancements in the context of biophilic designs and sustainable landscape practices

Hence this research seeks to explore the potential of biomimicking the geomorphic formation of Barchan Dunes landform for potential integration in sustainable landscape practices to assist in addressing major environmental concerns using a nature-inspired approach. By analyzing Barchan Dune's unique geomorphological setting the research will provide valuable insight to bridge the gap in knowledge in creating adaptive, resilient, nature-inspired landscapes that could foster a harmonious coexistence between man and his environment.

DEFINITION OF TERMS

To facilitate the understanding of this research, different terms are defined herein. Biophilic Design is about learning from nature and creating artificial environments that support and revive human biophilic nature by recreating, using, modeling, and extracting nature [8].

Sustainable landscaping is a modern type of gardening or landscaping that takes the environmental issue of sustainability into account. Sustainable landscapes are responsive to the environment, re-generative, and can actively contribute to the development of healthy communities. Sustainable landscapes sequester carbon, clean the air and water, increase energy efficiency, restore habitats, and create value through significant economic, social, and, environmental benefits [9].

Geomorphology is the study of the formation process of landforms and sediments on the Earth's surface. The Encyclopedia of Geomorphology defined geomorphology as “the area of study leading to an understanding of an appreciation for landforms and landscapes, including those on continents and islands, those beneath oceans, lakes, rivers, glaciers and other water bodies, as well as those on the terrestrial planets and moons of our Solar System” [10]

Barchan, crescent-shaped dune produced by the action of wind predominately from one direction. One of the most common types of dunes occurs in sandy deserts all over the world. Barchan Dune is a large, crescent-

shaped dune lying at right angles to the prevailing wind and having a steep, concave leeward side with the crescent tips pointing downwind [11].

METHODOLOGY

In the exploration of integrating biophilic design principles into sustainable landscape practices with a particular emphasis on the geomorphological aspect of Barchan Dunes, a meticulous mixed-method approach was employed. This approach combined qualitative insights with quantitative analyses to bridge theoretical principles with their practical applications, thereby facilitating a comprehensive understanding of the subject matter.

The study commenced with the development of structured and semi-structured survey questions designed to gather expert opinions and stakeholder perspectives from the fields of landscape architecture, environmental science, and geomorphology. The survey sought to uncover the perceived relevance and application of biophilic design in landscape practices, identify the challenges and opportunities of incorporating these principles in dune-dominated landscapes, collect examples of successful biophilic design implementations in arid or semi-arid environments, and solicit recommendations for leveraging geomorphological features in sustainable landscape design. Field observations were conducted across two primary locations renowned for their distinctive barchan dune formations, chosen to facilitate a comparative analysis and to underscore the research's relevance. The Taklamakan Desert in the Xinjiang Uyghur Autonomous Region of China, known for its extensive sand dunes, served as the first location. This desert landscape provided a broad array of barchan dune formations for morphological study. The second location was the Bilma region in eastern Niger, situated near the border with Chad. As part of the vast Sahara Desert, this area allowed for close examination of barchan dunes, contributing to the comparative study between different desert environments.

To enrich the research, five case studies were meticulously selected based on their successful integration of biophilic design principles within landscapes featuring dune formations. These included the Al Ain Oasis in the United Arab Emirates, an exemplar of vegetation and water management in a desert landscape [12]; Sossusvlei in Namibia, known for its high red dunes and conservation efforts [13]; White Sands National Park in New Mexico, USA, showcasing the use of native plants to minimize human impact on gypsum dune fields [14]; Dubai Desert Conservation Reserve in the United Arab Emirates, highlighting desert land rehabilitation and conservation of native flora and fauna [15]; and Lencois Maranhenses National Park in Brazil, offering insights into water management and conservation in dune ecosystems with seasonal rainwater lagoons [16].

The qualitative component of the research was underpinned by these case studies, field observations, and expert interviews, providing a rich foundation for understanding the practical application and challenges of biophilic design in arid environments. Concurrently, a robust quantitative analysis was carried out, employing remote sensing technology and GIS for spatial mapping and analysis of dune morphologies across the study locations. This was complemented by the use of bio-inspired algorithms in MATLAB and Python to process environmental data and uncover patterns of dune formation and evolution indicative of sustainable design potential.

RESULTS

The research study on integrating biophilic design approaches for sustainable landscape practices, with a focus on the geomorphological study of Barchan Dunes, revealed significant results that underscore the intricate relationship between environmental parameters and the morphological characteristics of Barchan Dunes. Through a detailed analysis combining field observations, expert consultations, and advanced computational techniques, the study validated a discernible correlation between environmental factors and the morphology of these dunes, thus providing a foundation for innovative sustainable landscape practices.

In-depth analysis of the survey data collected from the Barchan Dunes in the Taklamakan Desert and the Bilma region presented a comprehensive understanding of the dunes' formation. The quantitative analysis, facilitated by remote sensing and GIS technologies, indicated that the size, shape, and orientation of the dunes are significantly influenced by wind speed and direction, sediment supply, and vegetation cover. For instance, dunes in areas with higher wind velocities exhibited steeper leeward slopes and sharper crest lines, while regions with substantial vegetation demonstrated slower dune migration rates and more stabilized dune forms.

Moreover, the morphological analysis of Barchan Dunes, supported by MATLAB and Python algorithms, unveiled patterns in dune shapes and orientations that correspond closely with prevailing wind patterns and sediment availability. Dunes with limited sediment supply tended to be smaller and more widely spaced, whereas areas with abundant sediment showed larger, more densely packed dunes. These findings are critical for understanding the dynamics of dune ecosystems and their potential integration into biophilic design. The environmental data analysis further clarified the correlation between climatic conditions and dune morphology. For example, variations in annual precipitation and temperature were found to influence vegetation growth on the dunes, which in turn affects dune shape and movement. Dunes in regions with higher precipitation levels showed increased vegetation cover, leading to more stabilized dunes with less pronounced migration patterns. This direct linkage between environmental parameters and dune morphology validates the potential of incorporating geomorphological insights into biophilic design principles for sustainable landscape practices. These results not only confirm the hypothesized correlation between environmental factors and the morphological characteristics of Barchan Dunes but also highlight the significance of adopting a multi-disciplinary approach in landscape architecture. The integration of geomorphological knowledge into biophilic design enables landscape architects to create designs that are not only aesthetically pleasing but also ecologically sound and sustainable. By leveraging the natural dynamics of dune formation, landscape practices can promote resilience, sustainability, and a deeper connection between humans and their natural environment.

The implications of these findings have the potential to extend beyond the academic realm into practical applications in landscape architecture and other disciplines. By understanding the natural processes governing dune morphology, designers can create more sustainable and adaptive landscapes that respond to environmental changes, mitigate desertification, and enhance ecosystem services. This research paves the way for future studies to explore innovative design strategies that harmonize human activities with the natural dynamics of desert landscapes, ultimately contributing to the advancement of sustainable development and the well-being of communities living in arid and semi-arid regions.

CONCLUSIONS

The research explored the potential integration of Biophilic Design principles into sustainable landscape practices, focusing on the geomorphological aspect of Barchan Dunes. The meticulous analysis, rooted in a combination of qualitative insights and quantitative data, has confirmed a significant correlation between climatic conditions, vegetation cover, and the physical attributes of the dunes. This study not only deepens our comprehension of the natural processes shaping our environment but also reinforces the potential of leveraging this knowledge in the realm of biophilic design to foster sustainable, resilient, and aesthetically engaging landscapes. The findings underscore the importance of adopting a multidisciplinary approach in landscape architecture, one that harmoniously integrates ecological principles with design practices to create environments that are in tune with nature's dynamics.

Moving forward, the insights garnered from this research hold promising implications for the future of landscape architecture and sustainable practices. By integrating the geomorphological insights of Barchan Dunes into biophilic design strategies, there is an immense potential to enhance the sustainability and resilience of landscapes, particularly in arid and semi-arid regions. The research illuminated the potential for

innovative, sustainable landscape practices that harmonize with the natural dynamics of desert ecosystems towards more eco-conscious design practices that respect and reflect the inherent patterns of nature. Furthermore, this research marks a step forward in our journey towards more sustainable and harmonious interactions between humanity and the natural world, paving the way for future innovations in landscape design that are deeply rooted in the principles of biophilia and sustainability.

ACKNOWLEDGMENTS

Words cannot express my thanks to my parents, brothers, and sisters for their unconditional love and continued support. I am ever grateful for your encouragement and wisdom. My sincere gratitude to the Beijing Forestry University and the International College for giving me the golden opportunity to pursue my dreams. I acknowledge the support of my supervisor Associate Professor Cao Xin for the opportunity to conduct the research and for providing valuable knowledge and guidance throughout the research. I wish to express my gratitude to the following experts for their invaluable contributions and insights during this research: Maimuna Saleh, Ge Xingyan, Adeeb Asham, Pham Duc Long, He Xin, Chheng Sreyneang, Asma Ameerah Islam, Aminu Zubair, Yan Pengpeng, Alameen Toro, Marwa Damang, Amel Al-Sharani, Elaf Nabil Esmail, Dorcas Adebajo, and Zhanghao. Their diverse expertise across various fields significantly enriched this work. I acknowledge the use of Grammerly Ai to summarise my revision process and proofread my final draft. I highly acknowledge the support and encouragement I receive from my friends, classmates, and colleagues, their company made my study experience truly enjoyable. I owe a lot of gratitude to every person who participated and contributed to the cause of this research, the study would not have been possible without you. Thank you all.

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LOGISTICS DELIVERY MODEL SELECTION BASED ON FUZZY ANALYTIC HIERARCHY PROCESS

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ABSTRACT

As e-commerce logistics evolves, the logistics industry is diversifying its delivery methods. Different logistics delivery models are tailored to suit various enterprise sizes and application scenarios due to several factors, such as, scale of operations, costs, and flexibility requirements. The goal of this manuscript is to propose an evaluation model to assist e-commerce enterprises in choosing their logistics delivery models. Grounded in the theory of sustainable development, the proposed model, which is based on the Fuzzy Analytic Hierarchy Process (FAHP), integrates environmental, social, and economic measures together with consumer dimensions to determine the optimal delivery model. A case study in China is applied to demonstrate the feasibility and practicality of the proposed model. This paper offers valuable insights for the selection of logistics delivery models by e-commerce enterprises.

Keywords: Logistics distribution model; Fuzzy analytical hierarchy process (FAHP); E-commerce logistics; Sustainability

INTRODUCTION

Sustainable development is key for competitiveness in today's intense market. In the logistics filed, a delivery model does not only significantly influence the consumer shopping experience but also directly showcase the company's service capabilities and image. Therefore, logistics delivery has become a competitive focus for major e-commerce enterprises [1].

The main delivery models currently adopted include self-operating, outsourcing, joint delivery, and crowdsourcing. The self-operating delivery model refers to logistics companies handling their own deliveries, which entails high costs but offers better control.

Given the necessity of pursuing a sustainable development, environmental, social, and economic dimensions are essential factors to be considered simultaneously when selecting a delivery model [2]. Moreover, since the choice of delivery model is the only segment in the logistics service that directly interacts with end customers, consumer experience is also of paramount importance in this process [3].

In this context, this study proposes an evaluation model based on the Fuzzy Analytic Hierarchy Process (FAHP) [4,5] to support companies in selecting a delivery model. To enhance the model's comprehensiveness and practicality, it integrates not only the consumer perspective but also environmental, social, and economic factors into the decision-making criteria. Accordingly, the contributions of this paper are as follows: firstly, the study focuses on logistics delivery models, where existing research primarily targets logistics provider selection with scant attention to delivery model choices. Secondly, it integrates environmental, social, economic, and customer dimensions into the FAHP method, thereby developing a novel selection model. Lastly, a case study in China is applied to demonstrate the feasibility and practicality of the proposed model.

THE PROPOSED FAHP-BASED MODEL

The FAHP is a multiple-criteria decision-making analysis tool that integrates fuzzy logic with the Analytic Hierarchy Process (AHP) [6]. While fuzzy logic is employed to handle the uncertainty and imprecision in

evaluating criteria, AHP facilitates the structuring of decision problems into a hierarchical framework of more easily contemplated sub-problems [7]. FAHP has been applied across various fields [8], especially in logistics [9,10]. Considering the complexity of selecting logistics delivery models, which requires a thorough evaluation of multiple criteria and faces complications due to the inherent subjectivity and uncertainty of evaluators, applying the FAHP method is deemed highly suitable for simplifying this process.

FAHP includes the following steps: developing an evaluation index system, determining the weights of the indices, collecting fuzzy evaluation information, and computing the results to select best alternative. In the following sections, we will focus on the first and third steps.

DEVELOPMENT OF THE EVALUATION INDEX STRUCTURE MODEL

The first step in applying the FAHP method involves decision-makers breaking down complex multi-criteria decision-making problems into their constituent parts, with each potential criterion being organized into multiple levels or sub-criteria.

A variety of factors influence the selection of delivery models. After a literature review and experts consultations, an evaluation index system was developed. This figure shows that the hierarchical model comprises four levels. The first level states the overall problem's objective, whereas the second refers to the evaluation criteria. The third includes the sub-criteria based on the previous level, and the final level represents the delivery model alternatives.

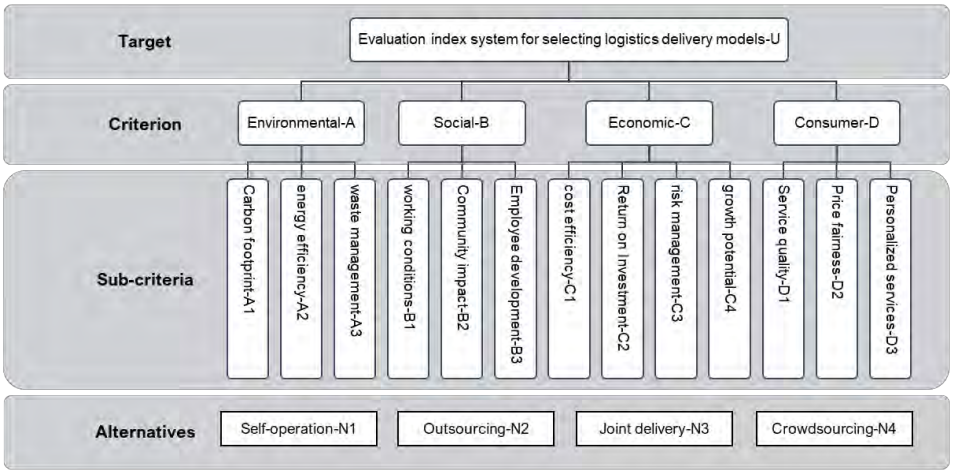

Figure 10- The evaluation index system for selecting logistics delivery models

QUESTIONNAIRE DESIGN FOR FUZZY EVALUATION

In regard to the third step, collecting fuzzy evaluation information, to collect respondents' assessments of the performance of various delivery models, we designed questionnaire items based on the index system, as presented in Table 6. A five-point Likert scale was adopted because it allowed respondents to easily understand and express their level of agreement/sentiment towards a particular statement.

Table 6- Questionnaire design

Criterion	Sub-criteria	Questionnaire Item	Delivery model - N_i				
			5	4	3	2	1
Environmental	Carbon Footprint	Please evaluate the efficiency of this delivery mode in reducing greenhouse gas emissions.					
	Energy Efficiency	Does this delivery mode meet your expectations in terms of energy consumption and efficiency management?					
	Waste Management	Please evaluate the effectiveness of this delivery mode in packaging material recycling and waste disposal.					

Criterion	Sub-criteria	Questionnaire Item	Delivery model - N_i				
			5	4	3	2	1
Social	Labor Conditions	How do you view this delivery mode in terms of work environment and health and safety assurances for employees?					
	Community Impact	Is the impact of this delivery mode on the local community (such as employment, social services) positive or negative?					
	Employee Development	Does this delivery mode provide sufficient training and development opportunities for employees, including education and career advancement?					
Economic	Cost Efficiency	How do you evaluate this delivery mode in terms of cost control and service efficiency?					
	Return on Investment	How do you assess the financial stability and profitability of this delivery mode?					
	Risk Management	Does this delivery mode manage operational risks sufficiently well?					
	Growth Potential	How do you see the potential for business expansion and market share growth with this delivery mode?					
Consumer	Service Quality	Does this delivery mode meet your expectations in terms of timeliness, reliability, and service attitude?					
	Price Fairness	Do you think the pricing of this delivery mode is fair and reasonable?					
	Personalized Service	How does this delivery mode perform in meeting personalized needs?					

Numerical values 5, 4, 3, 2, 1 represents the categories Excellent, Good, Average, Poor, Very Poor.

CASE STUDY

To validate the feasibility of the proposed evaluation model, we applied it to a Chinese e-commerce enterprise. In this section, we briefly describe this application. Readers should note that some of the implementation steps were omitted due to space constraints; however, all relevant details can be provided upon request.

DETERMINING THE WEIGHTS OF THE INDICES

We calculated the weights using classical AHP. Given that there is a single general manager overseeing logistics operations in our case company, we sent the evaluation index system to the company's general manager to assess the importance of each sub-criterion on a "1-9" scale to form a judgment matrix. By calculating their eigenvectors, we determined the weights. This process also includes a consistency check to ensure the accuracy and reliability of the evaluation. Table 7 presents the wrights and rankings, demonstrating that the primary factors influencing the choice of delivery model for enterprises include cost efficiency, return on investment, service quality, and personalized services.

Table 7 – The comprehensive weights and rankings of indicators

Criterion	Weight	Sub-criterion	Weight	Comprehensive weight	Ranking
Environmental-A	0.074	Carbon footprint-A1	0.117	0.009	13
		Energy efficiency-A2	0.615	0.046	8
		Waste management-A3	0.268	0.020	12
Social-B	0.113	Working conditions-B1	0.196	0.022	11
		Community impact-B2	0.493	0.056	6
		Employee development-B3	0.311	0.035	10
Economic-C	0.549	Cost efficiency-C1	0.49	0.269	1
		Return on Investment-C2	0.225	0.124	2
		Risk management-C3	0.195	0.107	5
		Growth potential-C4	0.09	0.049	7
Consumer-D	0.264	Service quality-D1	0.417	0.110	3
		Price fairness-D2	0.166	0.044	9
		Personalized services-D3	0.417	0.110	4

FUZZY EVALUATION

In this step, 10 experts in Logistics assessed the performance of different delivery models N_i, namely, self-operating N_1, outsourcing N_2, joint delivery N_3, and crowdsourcing N_4, using Table 6. Based on the experts' responses, we derived statistical frequency data and established the fuzzy evaluation matrix of each model. Each model's matrix presents the fuzzy evaluation vectors B_i.

DEFUZZIFICATION AND DECISION-MAKING

In this step, we assigned scores to the Likert scale, set as $V^T = (100 \quad 80 \quad 60 \quad 40 \quad 20)$. We multiply the fuzzy synthesized evaluation vector obtained in the previous step by these scores to calculate the comprehensive assessment values for each option, $\mu_i = B_i * V^T$. As the self-operating delivery model presented the highest comprehensive assessment value μ_i, one can say that this model outperformed the other models for the case company. Therefore, this model was recommended for the case enterprise. The self-operating delivery model requires significant initial investment but offers direct operational control, which enhances service quality and facilitates long-term strategic adjustments, leading to cost savings and higher investment returns. Additionally, it provides direct management of quality and service standards, conducive to developing personalized services, thus improving customer satisfaction and market competitiveness.

CONCLUSIONS

This paper has developed an evaluation index system based on FAHP which focuses on environmental, social, economic, and consumer factors. The model offers valuable insights for businesses navigating delivery model selection. However, the dynamics of societal infrastructure, technological advancements, and shifts in consumer and business ideologies significantly impact logistics delivery models. Consequently, the evolution of the evaluation index system should align with the dynamic changes in environmental, social, economic, and consumer factors to meet evolving decision-making requirements.

ACKNOWLEDGEDMENTS

The authors used ChatGPT to check grammar issues and to improve readability.

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THE E-COLAB PLATFORM AND ITS DEVELOPMENT: AN APPROACH BASED ON PDCA CYCLE

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ABSTRACT

In recent years, the demand for resources has not stabilized, pushing the linear economy even further along a unidirectional path of take-produce-discard, aggravating environmental problems. Thus, this work aims to present the E-COLAB project, a platform to facilitate reverse logistics in accordance with the National Solid Waste Policy, promoting business interaction, adequate disposal of materials and encouraging Circular Economy practices. The platform development follows the PDCA methodology, which is a method of continuous improvement for process and consists of four stages: Plan, Do, Check, and Act. In version 1.0 of the platform, the need for improvements in the interface was identified, initiating the second PDCA cycle. Currently, version 2.0 is under development to enhance the user experience and platform effectiveness, aiming for continuous evolution.The expected results of the research are that the platform will be used by companies to promote circularity and reuse the waste generated. The next stages involve the consolidation of version 2.0 of the platform, followed by the registration of companies and dissemination to city hall, NGOs and other organizations. E-COLAB should be a free access portal that can support reverse logistics activities following PNRS and boost the implementation of Circular Economy principles among the organizations.

Keywords: Waste Management; Circular Economy; Reverse Logistics; Information System.

INTRODUCTION

In the last 50 years, the demand for resources has not been stabilized, causing serious environmental problems, including air, water and soil pollution, scarcity and depletion of resources, in addition to climate change [1]. One of the main causes of these problems is the dominant linear economic model, in which resources and products move in a unidirectional flow like take-make-dispose [1]. The circular economy (CE) emerges as an alternative model to the traditional linear economic system, promoting the circularity of materials through Reverse Logistics (LR) practices such as reuse, remanufacturing and recycling [2].

In Brazil, despite the absence of specific regulations on the CE, the National Solid Waste Policy (PNRS) - Law No. 12,305/2010 addresses waste management and, together with the Environmental Crimes Law, provides punishments for offenders [3]. Recent studies by the Ellen Macarthur Foundation point out that technological advances, guided by CE, facilitate knowledge sharing, material tracking and improve logistics and reverse logistics configurations [4]. These digital technologies are essential factors to support the implementation of CE in companies [5].

Therefore, this work aims to present the E-COLAB project, which consists of developing a platform to support reverse logistics in accordance with the National Solid Waste Policy, promoting interaction between companies and facilitating the appropriate disposal of materials at the same time, promoting the implementation of Circular Economy principles. The project is being developed to meet the Sustainable Development goals “Sustainable Cities and Communities”, “Responsible Consumption and Production” and “Life on Land”.

MATERIALS AND METHODS

Version 1.0 of the E-COLAB platform is available at https://empresas.e-colab.ufscar.br. All development of the E-COLAB platform has been taking place through the PDCA cycle, which is a method of continuous improvement for process or systems management. This cycle is made up of four stages: Plan, Execute, Check and Act and is designed to be used as a dynamic model in which the completion of one cycle will flow into the beginning of the next cycle, and so on. The first phase (PLAN) consists of locating the problem and establishing goals for creating an action plan. The second phase (DO) executes the actions established in the action plan defined in the previous phase [7]. In the third phase (CHECK), the effectiveness of the actions taken in the previous phase must be verified [7]. Finally, the fourth phase (ACT) consists of taking corrective and preventive measures to further standardize processes, which can serve as a starting point for a new cycle of continuous improvement [7].

Considering the 1st PDCA cycle, the conceptual development of version 1.0 of the E-COLAB platform was planned in (PLAN). In the second phase, (DO), E-COLAB was developed considering the functional requirements previously defined in the previous phase. In the third phase (CHECK), usability tests and interviews were carried out with real users from companies in the reverse chain to validate the platform and identify usability problems, as suggested by the Empirical Method[8]. After completing the tests and interviews, the results were analyzed, this being the last phase, ACT, of the PDCA cycle. The execution of the 1st cycle for the development of the E-COLAB platform took place through extension and technological initiation projects, involving students from the Computer Science and Production Engineering courses at Federal University of São Carlos (UFSCar)- Sorocaba.

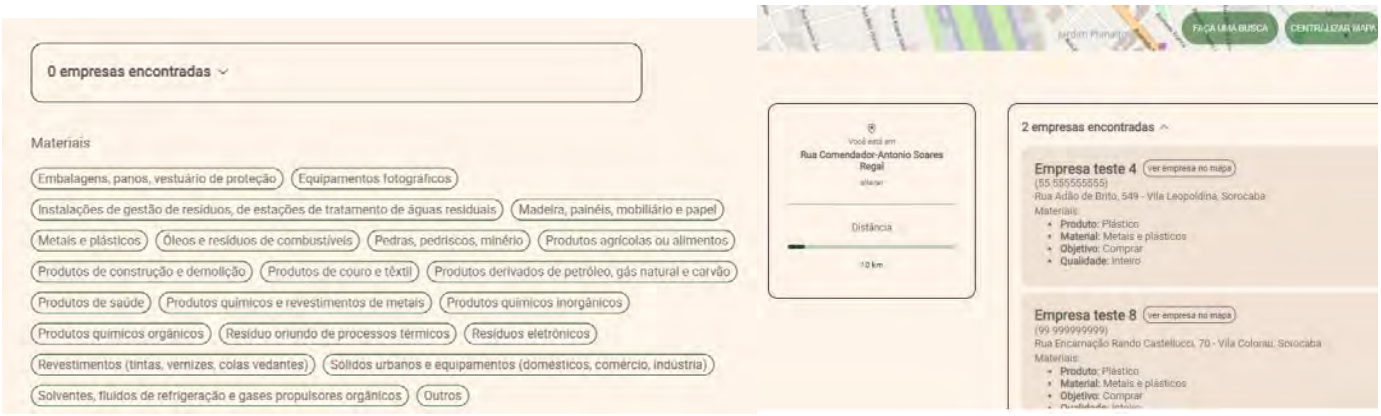
The second cycle is in the execution phase, and the new functionalities and interfaces of the platform (PLAN) have been planned and can be viewed through Figma E-COLAB v2.0. In the second phase (DO), which the project is currently in, the changes proposed according to the interviewees' suggestions are being implemented on the platform. After completing this stage, the next step (CHECK) will be to validate version 2.0 with potential users, aiming to collect new suggestions for improvement and register companies on the platform. Finally, in the last stage (ACT), the platform will be promoted among companies, city halls, and NGOs, to further expand the number of registered companies.

RESULTS

The 1st PDCA cycle highlighted the need for improvements in version 1.0 of the E-COLAB platform. Figure 1 illustrates the initial search screen for this version. Initially, users are advised to read the usage information contained on four pages before using the available features. After registering the company and the materials available in the “Company Area" interface, the user can carry out queries in the “Search” interface applying filters for distance, type of material, objective, volume and quality. The query results can be viewed on maps, using the user's current location as a reference, as shown in Figure 1. Furthermore, the platform includes a "Contact" section for communicating with the support team and a "Who we are" section, highlighting those responsible for its development and their contributions to the UN 2023 sustainable development goals.

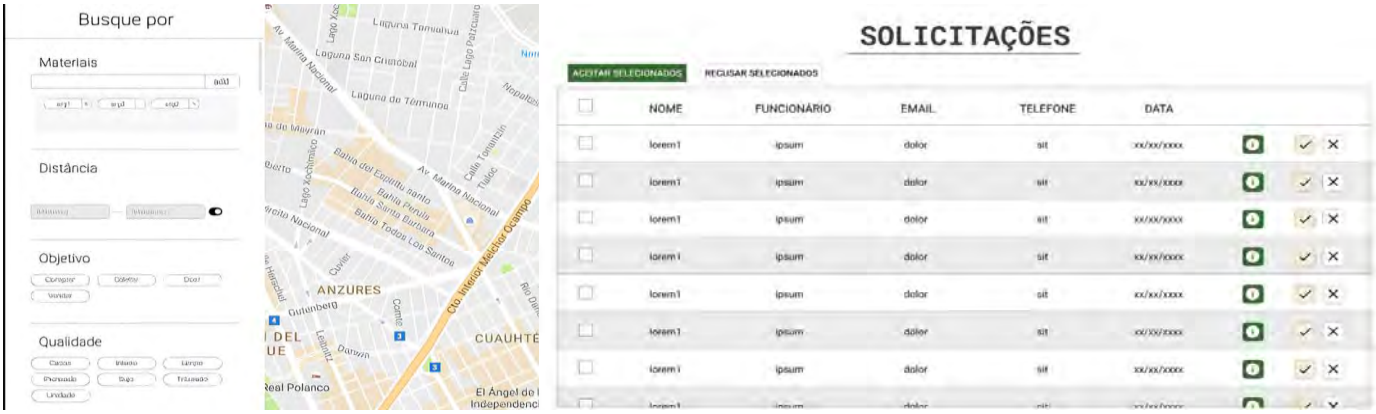
To evaluate these functionalities and the usability of the platform, interviews were carried out with potential users and an evaluation questionnaire was applied. As a result of this process, most of the functional requirements were considered essential or important by the evaluators, with some needs not yet addressed such as: the inclusion of a Chat with the companies, another to Remove types and quantity of each waste by the companies, in addition to the Query and change company data when logging in/out. With this, the 1st PDCA cycle of the development of the ECOLAB platform was concluded.

Figure 1: E-COLAB v1.0 initial screen for consulting companies by material



The 2nd cycle began with planning the modifications suggested in the previous cycle. Improvements are being implemented on the platform based on feedback received during interviews, questionnaires and usability tests, generating version 2.0 of the E-COLAB platform. Figure 2 illustrates the “Search” screen of the new version. In addition to this screen, a “Home” interface with a dashboard is also being included, aiming to convey security and credibility of relevant results to the user, such as the number of registered companies and quantity of materials recovered, among others. Furthermore, a “Company Registration” page was developed separately from “Company Login” to facilitate the process of including new organizations and authenticating users on the platform. There is also a new interface for registering materials, where it is possible to view all materials already registered by the company, making it easier to add, edit or delete any material.

Figure 2: E-COLAB v2.0 material company search “home page” and request control page



Additionally, a new module named "Admin" has been included for platform maintainers. This module included the implementation of a company CRUD, enabling more efficient management of business information stored in a database. Furthermore, the Accept/Reject company registration functionality was included, providing greater control over the adhesion of new organizations to the platform, as can be seen in Figure 2.

So far, the expected results of this project have been achieved in the short-term, such as the validation of functionalities and usability by platform users. The result showed that 100% of respondents said that the E-COLAB platform would help in the purchase/sale of materials for their company and they would use it frequently for this purpose.

The expected long-term results of the research are that the platform will be used by companies to promote circularity and reuse the waste generated. The next stages of project development involve the consolidation of version 2.0 of the platform, followed by the registration of companies and dissemination to city hall, NGOs and other organizations

CONCLUSIONS

As shown, the E-COLAB platform is in the development process and is undergoing improvements to be incorporated into its 2.0 version. These improvements, guided by the PDCA approach, guarantee a continuous process of improving the platform's functionalities and interface, to achieve the main objective of promoting interaction between companies involved in the reverse chain, facilitating the "exchange" of different types of materials through purchase, sale, donation or collection.

Based on the results obtained in the validation of functionalities and usability in version 1.0, and the implementation of improvements for version 2.0, the aim is for E-COLAB to be a portal that facilitates the correct disposal of waste and can support logistics activities reverse according to PNRS and boost the implementation of Circular Economy principles among organizations, NGOs and other institutions.

ACKNOWLEDGEDMENTS

The authors DeepL.com translator in order to check grammar issues and to improve readability.

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