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In my beginning is my end

Martin Dodman, Elena Camino, Osman Arrobbio, Enzo Ferrara, Giuseppe Barbiero

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All life is sustained by what has been before. The atoms of any living organism or non-living entity have been recycled innumerable times and in countless different forms of biotic and abiotic matter, including the biochemical characteristics of the genome of LUCA, the presumed last universal common ancestor of all living organisms, dating back to over four billion years ago (Moody et al., 2024). Since then, biogeochemical cycles have reiterated this process, constantly producing, disrupting and newly producing a potentially infinite range of different biospheric equilibria and the resulting ecosystems, ecological communities and populations of species that ensue.

In this respect, what is often referred to as the Anthropocene is no more than a particular example of this ongoing succession of change(s). What most characterizes it, however, is the tendency of one species, *Homo sapiens*, to continually disrupt existing balance(s) through both the strength and the velocity of its impacts, in terms of relentless exponential demographic growth, plundering physical resources to an extent that far exceeds their natural replenishment, exploiting indiscriminately living organisms – including fellow human beings – even to the point of rendering them at risk of extinction, destroying habitats through urbanization and expansion of agricultural land, so as to cause a drastic loss of biodiversity, accelerating production and consumption chains that massively pollute and generate volumes of waste that overwhelm natural recycling processes and degrade environments, thereby threatening the planetary health balance on which our wellbeing depends, together with that of countless



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other species. All this is then infinitely exacerbated by constantly waging intraspecific war at increasingly devastating levels, and consequential mass destruction of habitats and ecosystems, together with wholesale suffering and death for human and all life.

The essence of the question can be seen in terms of the laws of physics. Power (P) is the product of force (F) and speed (s). Power can also be expressed as the ratio of work (W) to time (t). Doing a given amount of work in a shorter time means increased power. When *human time* taken to destroy balance is shorter than *Nature time* needed to recover, the outcome is unsustainable. This is further exacerbated in those areas where intensity - defined as the ratio of power to surface area - is at its maximum, thereby straining to breaking point an ecosystem's carrying capacity.

Such human *hubris*, compounded by the unprecedented power certain technologies and systems have conferred on modern societies, without corresponding governance mechanisms able to manage their consequences, means that we have largely continued to ignore the fact that resource ceilings and carrying capacities cannot be ceaselessly exceeded and human-inflicted devastation relentlessly pursued without dramatic consequences. If as a collective species we will be able to recognise this before it is too late, such recognition necessarily means we must exit from our dominant Western anthropocentric vision and reconsider our existence in terms of its beginnings and ends at various levels and in terms of the material and immaterial processes that characterize our trajectories. Each one of the papers in this issue can be seen as explorations in that direction.

In terms of material processes involving beginings and ends, in recent years much attention has been paid to the concept of Circular Economy (CE). In "Bridging ESG and the Circular Economy. Advancing corporate sustainability through the updated R-hierarchy and Circularity Scoring Model" Kopnina et al. offer an innovative vision for CE. They explore how CE and Environmental, Social, and Governance (ESG) frameworks can intersect by integrating relevant theories and practical approaches to enhance organisational alignment and accountability, in particular regarding the environmental dimension. They propose an updated 10-R framework for qualitative reporting, incorporating new dimensions such as Regeneration (e.g., Rewilding and Restoration) to reflect biodiversity considerations, together with the Circularity Scoring Model (CSM) to quantitively assess organisational CE performance concerning ESG objectives, and report findings suggesting that embedding CE principles into accounting and investment practices can highlight opportunities for improvement in key areas of sustainability.

While Kopnina et al. present a macro-framework for CE, two following papers offer micro-visions for circularity in waste management. In "Cocoa shell bioplastic: a circular path towards sustainability" Burgos Bravo et al. investigate the potential of cocoa shells as feedstock for bioplastic synthesis. They compare two treatments for filtration, solubility, elongation, resistance, moisture content, and biodegradability and conclude that in both cases results show cocoa shells can offer a sustainable and environmentally friendly resource for bioplastic production, contributing to a circular economy and reducing agricultural waste. In "Enhancing compost quality with *bacillus* bacteria: Leveraging cocoa shells and banana *pseudostems*" Basurto et al. examine different treatments to evaluate *Bacillus albus* and *Bacillus miedmannii* for composting banana *pseudostem* and cocoa shell waste. Their results show the important role of composting in recycling and reducing the polluting impact of agricultural waste.

Higher education clearly has a key role to play in creating the necessary awareness of the paradigmatic changes necessary for promoting more sustainable human trajectories. In "Assessing campus sustainability practices. A systematic literature review" Putra & Ulkhaq set out to evaluate sustainability practices in Higher Education Institutions (HEIs), focusing on assessment frameworks and methodologies. Their findings reveal the adoption of diverse frameworks, together with the integration of sustainability principles into curricula, campus operations, and research. The authors show challenges such as resource constraints, limited stakeholder awareness, and infrastructural barriers hinder effective implementation and highlight the need for comprehensive, localized assessment tools to enhance HEIs' contributions to promoting sustainability.

Attention has also been increasingly directed to indigenous knowledge and local wisdom and how this can be related to understanding mutually beneficial relationships between human populations and populations of other species within ecological communities. In "Leveraging selected Local Wisdom Species in developing peatland restoration in South Sumatra, Indonesia" Armanto et al. examine applying Local Wisdom Species (LWS) to involve rural communities in peatland restoration. They argue that if LWS disappear due to pressure from industrial plantations, rural communities will be controlled by the international trade system, which threatens their rural lifestyles, and they will be pushed out of the peatlands where they have lived for hundreds of years and propose rural community-based peatlands restoration based on four approaches that focus on decentralization, conservation, protection and optimization.

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Local wisdom can be seen as the outcome of living in balance with all the biotic and abiotic components of one's environment, and this also been linked with a growing recognition of the importance of a relationship with nature that enhances health promotion. In "Mountain Therapy as a support in breast cancer treatment. A pilot study in Southern Italy" Piattelli et al. illustrate research on Mountain Therapy (MT) as a therapeutic-rehabilitative and/or socio-educational methodological approach aimed at the secondary prevention, treatment and rehabilitation of people with different pathologies. The main results show that the patient's quality of life improved after the MT approach, reducing stress and anxiety levels, thereby confirming the regenerative capacity of the natural environment in people suffering from a disabling disease, monitored through the assessment of psycho-physical parameters, helping to improve their quality of life and reduce hospitalisations.

The nature of and the relationship between human activity, urban expansion and various kinds of natural habitats, including forests, is a key question in much sustainability literature. In "Sustainable approach for socio-ecological development of urban areas" Chhachhiya et al. explore the multifaceted dimensions of resilient and inclusive urban planning, focusing on its significance amidst urban expansion and socio-economic disparities affecting the corresponding ecologically sensitive areas. The authors examine the theoretical underpinnings and practical applications of resilience and inclusivity within urban planning frameworks. They highlight the importance of integrating eco-sensitive approaches, adaptive strategies, and participatory mechanisms to foster resilience and inclusiveness in urban development processes. In "The effect of tree harvesting rights on investment in tree growing and promotion of sustainable tree conservation practices by private land holders in Kenya" Chisika & Yeom use a case study approach and document content analysis to examine the impact of assigning tree harvesting rights on sustainable tree growing. Their results show that, while assigning tree-growing rights has had positive impacts, including ecological and economic benefits, it has also led to negative sustainability outcomes. They argue that developing a stable legal framework, improving market access, and offering financial incentives are crucial for supporting sustainable forestry on private lands.

New visions are always built on the basis of current and previous visions. This involves understanding how narratives, discourses and dialogues evolve and can be unconsciously subscribed to or questioned and thereby changed. In "Terror Management Theory and grand-metanarratives. The search for a consilient ethics of conscious limitedness for the ecological transition" Sanniti et al. argue that it

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is essential to examine dominant ethical systems and whether they can be redirected to encourage sustainable behaviours. They draw on Terror Management Theory (TMT), which suggests that cultural systems evolve in response to humans' awareness of their biological limitations. They maintain that both individual and collective actions rely on a shared system of beliefs, or grandmetanarratives, that give meaning to experiences. Through examining the disembodiment metanarrative in the Western Judeo-Christian paradigm as central to the expansion of global beliefs, they propose a shift towards more ontologically open and epistemologically pluralist metanarratives that lay the foundation for the emergence of global and localized ecological consciousness.

In "Reinterpreting intercultural dialogue for sustainability in the Anthropocene era" Skrefsrud explores the concept of intercultural dialogue in an era shaped by significant human impact on the planet to show how an Anthropocene narrative can offer a critical and imaginative reassessment of that dialogue and extend its scope beyond traditional anthropocentric perspectives. The author argues the need for critical analysis within Anthropocene discourse, situating intercultural dialogue within an ecological context, and challenging dominant narratives, so as to amplify marginalized voices and foster more just and sustainable ways of coexisting.

In "The representation of nature in a political speech in promoting 'Indonesia Maju" Max et al. adopt an ecolinguistics approach to examine how topics on nature in political discourse and speeches are strategic not only to gain people's attention but also to hide agendas. Their research aims Systemic Functional Grammar's transitivity and Greimas' actantial analysis. The research object is a speech which promotes the notion of "Advanced Indonesia". Linguistically, the speech emphasizes green economy but neglects indigenous people and environmental concerns. Through an actantial analysis, the authors argue that in promoting "Advanced Indonesia" as the goal the speech neglects the nature it purports to promote by maintaining anthropocentric perspectives of the subject.

In "How can satirical fables offer us a vision for sustainability?", a book review of *Wild Wise Weird* by Quan-Hoang Vuong, Nguyen states that the book fosters readers' awareness, self-reflection, informational connectivity, and even inspires them to confront stupidity to uncover wisdom. The reviewer believes that it has the potential to resonate with readers, especially younger ones, embedding ecological sustainability in their humanistic values through the humor, vibrancy, and absurdity of its bird characters, as well as the wisdom woven throughout.

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In "A vision for just and fair transitions toward a carbon-free world", a book review of *A just transition for all: Workers and communities for a carbon-free future* by J. Mijin Cha, Pham & Ho state that technological visionaries often paint a future powered by clean energy, yet these optimistic visions tend to overlook the messy socio-political realities of such transitions. They argue that the book they review illustrates how there is a vast difference between a so-called 'just' transition and one that is genuinely just and offers a much-needed, thought-provoking, and meticulously documented exploration of how political and business leaders can ensure fairness and justice for all stakeholders - especially vulnerable workers and their communities - as the world attempts a shift toward a carbon-free future.

The title of this editorial is a line from the poem "East Coker" by T.S. Eliot. In a companion poem in the volume *Four Quartets* (1943), "Little Gidding", Eliot affirms:

What we call the beginning is often the end And to make an end is to make a beginning. The end is where we start from.

Ends can be points of arrival from which to derive new beginnings as points of departure. Ends can also be defined in terms of purpose and scope, to rethink trajectories and move from an anthropocentric to an ecocentric vision and begin anew the human enterprise. From another perspective, ends can also be the occasion for death and even extinction, something both auto-inflicted and hetero-inflicted on other species by *Homo sapiens*. As Edward Said (1975) puts it: "[...] beginning is basically an activity which ultimately implies return and repetition rather than simple linear accomplishment". If we continue to put our faith in a linear pathway of supposed progress based on economic growth and technological advance, then death and extinction will likely be our only accomplishment.

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Bridging ESG and the Circular Economy.

Advancing corporate sustainability through the updated R-Hierarchy and Circularity Scoring Model

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- 1. Introduction: Connecting circularity with the Environmental, Social and Governance
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 - 4.1. Circularity and ESG Connections
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 - 4.4. Strategic action linking ESG and CE
 - 4.5. Reflection of what remains unaccounted for
- 5. Conclusion and Recommendations

Acronyms: C2C: Cradle to Cradle; CE: Circular Economy; CSM: Circularity Scoring Model; ESG: Environmental, Social and Governance; NGO: Non-Governmental Organization.



Keywords: Circular Economy (CE); closed-loop production; Environmental, Social and Governance (ESG) factors; Circularity Scoring Model (CSM).

Abstract. This paper explores the relationship between Circular Economy (CE) and Environmental, Social, and Governance (ESG) frameworks – a connection that remains ambiguous in both academic literature and practical application. This lack of clarity hinders corporate accountability and progress toward sustainability goals. To address this, we examine how CE and ESG intersect by integrating relevant theories and practical approaches. We identify key strategic overlaps across diverse CE and ESG indicators and frameworks, demonstrating how each can inform and strengthen the other. We begin by outlining foundational theories and current practices in both CE and ESG, then explore how their integration can enhance organisational alignment and accountability, particularly in the environmental dimension of ESG. To support this synergy, we propose an updated 10-R framework for qualitative reporting, incorporating new dimensions such as Regeneration (e.g., Rewilding and Restoration) to reflect biodiversity considerations. Additionally, we introduce the Circularity Scoring Model (CSM) to assess organisational CE performance concerning ESG objectives quantitatively. Our findings suggest that embedding CE principles into accounting and investment practices can highlight opportunities for improvement, such as transitioning to renewable energy, sourcing alternative materials, extending product lifespans, enhancing repairability, minimising waste, and increasing use of recycled or regenerative resources.

1. Introduction: Connecting circularity with the Environmental, Social and Governance

This article addresses a vital issue in contemporary environmental management and corporate strategy – the relationship between circular economy (CE) and Environmental, Social and Governance (ESG) criteria. We critically analyse the link between CE and the E of the ESG, exploring how they can support long-term business goals, social and environmental value, and the ethical and transparent governance factors and systems required. CE is based on the concept of a closed-loop production system and requires innovation in inputs, processes, consumer relationships, and governmental

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regulations (e.g., Kopnina & Poldner, 2021; Kirchherr, 2022). ESG frameworks include sustainable finance, impact investment, positive screening, and sustainability disclosures that support long-term business, social, and environmental value, ethical and transparent governance factors, and systems required for this (e.g., Chouaibi & Affes, 2021). In capital markets, some investors use ESG criteria to evaluate companies and help determine their investment plans (Alkaraan et al., 2023a), a practice known as ESG investing (PWC, 2023; Stedman, 2023). At times, these investments are specifically linked to CE (Patil et al., 2021) and to the promise that "each principle of the circular economy can have a positive impact on biodiversity" (Ellen MacArthur Foundation, n.d.a).

Circular strategies are sometimes conceived as a 10-R scale hierarchy of sustainable production that ranges from absolute closing of the natural resource-production circle (refusal to make or buy new products, infinite reuse) to partial closing (recycling, downcycling) (Potting et al., 2010; Kirchherr, 2022). Notably, the R of Refuse in the model implies avoidance of production and consumption of non-circular or unsustainable production (which may not align with conventional business thinking), followed by the Rs of Rethink, Re-use, Repair, Reduce, Refurbish, Remanufacture, Repurpose, Recycle, and Recover (Potting et al., 2017). The higher a circular strategy is on the ladder, the tighter the waste loop becomes. This indicates that the strategy requires fewer materials and is therefore more circular. The 10-Rs range from closing (refusing or reusing), extending (prolonging usability through repair and re-use), intensifying (gaining more use in a shorter period), narrowing (using fewer resources), and dematerialising (reduction of total material and energy throughput at every stage of the production and consumption chain) (Bocken et al., 2016; Geissdoerfer et al., 2018a).

As discussed in the emerging literature linking ESG and CE, both are supportive of value networks involving diverse and at times conflicting interests of stakeholders, such as shareholders, employees, customers, suppliers, logistical service providers, members of civil society, nongovernmental organisations, the environment, and governments (e.g., Patil et al., 2021; van Langen et al., 2023; Babkin et al., 2023; Wamane, 2023). Considering varying accountability regimes in pluralistic societies (Brown et al., 2015) such links promise to make environmental sustainability meaningful, as the academic community and practice increasingly call for a broadened and more critical understanding of organisations' accountability concerning the environment (Bebbington et al., 2007; Gray, 2010; Busco et al., 2018).

Building on this literature, we argue that CE standards and practices have the potential to make the 'E' of the ESG framework more actionable and accountable and that ESG frameworks can make CE approaches more rigorous. Critical analysis shows that there is also a shift from "greenwashing to ESG-washing" in the circular economy field (Todaro & Torelli, 2024), especially when it comes to the claims that CE can have

beneficial effects on ecosystems and biodiversity (Ellen MacArthur Foundation, 2022; n.d.a). With the increased attention in environmental management literature to the topics of regeneration and conservation of biodiversity (Cavalcante et al., 2022; Kopnina et al., 2024; Han et al., 2024), it is surprising to see them disconnected from the mainstream CE and ESG indicators. Ellen MacArthur Foundation (n.d.b) popularises CE and stresses its importance for ecosystem regeneration, "enabling biodiversity to thrive", yet the 10-R hierarchy does not include Regeneration (including Rewilding and Restoration).

The first objective of this article is to articulate how the system of ESG reporting, rating, prioritising investments, and business strategy decisions impacts CE and vice versa. The second aim is to propose means to further analyse, compare, and quantify the circularity performance of organisations as part of ESG criteria, resulting in enhanced CE scoring and organisational accountability for biodiversity loss through an added regeneration dimension. Thirdly, we will analyse how aligning CE and ESG can help inform organisations and managers about planning, risk management, measuring, forecasting, innovating, or weighing opportunities or threats relating to sustainability and circularity principles. Considering these objectives, the research questions are:

- 1. How does the ESG framework influence the adoption and success of circular economy practices?
- 2. What tools and metrics can effectively measure and integrate circularity into ESG criteria?
- 3. How can the aligned CE and ESG frameworks inform better decision-making and foster accountability for sustainable and more circular operations?

These objectives drive the need to explore the intersection of CE and ESG frameworks. While ESG has become a key factor for investment decisions, especially in capital markets, there are concerns about "ESG-washing" concerning circular economy strategies. The authors aim to critically examine how the impact of ESG reporting, rating, and business strategies on CE and vice versa can be maximised to counter ecosystem decline and biodiversity loss.

The study emphasises that circular strategies, supported by both technological and social innovation, can be more rigorously applied within the ESG framework. Through an update of the existing 10-R framework and our introduction of the newly developed Circularity Scoring Model (CSM), we aim to bridge the gap between CE and ESG, standardising reporting and ensuring organisations enhance sustainability accountability. Below, we highlight the most strategic areas of overlap to bridge the gap between the dispersed studies of various matrices and indicators within ESG and CE. Finally, we discuss broader implications of opportunities that lead to value maximisation and threats

to circular operations. We advocate standardisation of qualitative reporting on CE themes via the updated 10-R framework and further develop the proposed CSM quantitative substantiation of the circularity performance of organisations as part of ESG criteria, resulting in enhanced circular accountability of organisations.

2. Methodology

This study adopts a desk-based research methodology to critically assess the fragmented relationship between Environmental, Social, and Governance (ESG) criteria and Circular Economy (CE) principles, to support more robust corporate sustainability practices. Recognising the current conceptual and practical disconnect between ESG frameworks and circularity metrics, we aimed to bridge this gap by proposing a novel evaluative approach: the Circularity Scoring Model (CSM). Our research process involved an extensive literature review conducted via major academic databases such as Web of Science, Scopus, and Google Scholar. We employed keyword combinations such as *"circular economy"*, *"closed-loop production"*, *"regeneration"*, *"ESG"*, *"Environmental, Social, and Governance"*, *"sustainability reporting"*, and *"corporate accountability"*. Boolean operators (AND, OR) were used to refine search outcomes and ensure comprehensive coverage.

Despite the value of scholarly databases, we identified a significant scarcity of integrated approaches directly linking ESG and CE, particularly concerning practical implementation and standardised metrics. To complement the academic insights, we expanded our scope to include industry white papers, professional blogs, and interdisciplinary sources accessed via standard web searches. This broader scope captured emerging frameworks, practitioner insights, and current discourse in the sustainability field.

To ensure quality and relevance, the literature was filtered using the following inclusion criteria:

- Published in 2016 or later, focusing on recent developments in CE and ESG.
- Addressed interdisciplinary themes, spanning business, environmental science, and sustainability accounting.
- Originated from peer-reviewed journals or credible grey literature produced by recognised institutions or experts.
- Written in English.

Insights gathered from this review directly informed the design of the Circularity Scoring Model (CSM). Instead of relying on existing models like the 9-R framework, we introduced a revised version of the R-Hierarchy, incorporating new dimensions such as

Regeneration, Rewilding, and Restoration - concepts that directly address biodiversity and ecological restoration within the environmental aspect of ESG. To demonstrate the model's application, we present an illustration (proof of concept) involving a Romanian agribusiness, selected through convenience sampling. One of the co-authors maintains a professional relationship with Circuworld¹, a technology provider specializing in circular economy solutions and organic waste valorisation, with complementary consultancy services. This affiliation provided first-hand access to internal data and operational insights necessary for applying the CSM in a real-world context. The case company was chosen for its ongoing circular initiatives. Using both qualitative and quantitative internal data, we applied the CSM to assess its current circularity performance and simulate the potential improvements achievable through targeted interventions. This example serves not as empirical validation, but as a practical demonstration of how ESG-CE integration can be operationalised and visualised within a corporate sustainability framework.

2.1 Data analysis

The selected literature was critically examined to identify overlaps, gaps, and synergies between ESG frameworks and CE practices. Particular attention was given to literature that addressed innovative CE practices and their potential to enhance ESG performance. Based on the findings, two key contributions were developed to bridge the gap between ESG and CE:

- Updated 10-R Framework: Expanding on existing CE models, we introduced two
 additional principles—Regeneration (including Rewilding and Restoration), —to
 address biodiversity and ecosystem-focused criteria. This updated framework
 provides a more holistic approach to CE by integrating natural capital regeneration
 into sustainability strategies.
- 2. CSM: Building on the gaps identified in qualitative reporting practices, the CSM was developed as a proof of concept to quantify the CE performance of companies and organisations. The model was designed to offer both versatility across industries and integration with existing ESG reporting frameworks. To demonstrate the model's practical application and validate its internal logic, we applied it to the available data of a Romanian agribusiness, offering early insights into its potential for broader use.

While the methodology provides a foundation for linking CE and ESG, certain limitations must be acknowledged:

 Theoretical Scope: The study primarily draws on existing literature and may not fully capture the nuances of emerging CE and ESG practices in specific industries.

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¹ <u>www.circuworld.com</u>

- Quantitative Validation: While the CSM provides a conceptual framework, further empirical research is needed to validate its application across diverse organisational contexts.
- Geographical Focus: The review primarily included sources with a global perspective, but regional variances in CE and ESG adoption were not deeply analysed.

3. Linking ESG and CE in theory and practice

The next sections will introduce ESG and CE theory and practice, before exploring how each can inform and reinforce the other. Its purpose is to provide clarity and insight into the link between ESG and CE by cross-fertilising between these streams of resonant theory and practice. We highlight the most strategic areas of overlap between the dispersed studies of various ESG and CE matrices and indicators. We propose a standard for qualitative reporting through an updated version of the 10-R framework. We introduce the CSM to help quantify the CE performance of organisations to link ESG targets. The reinvigorated theoretical synergy between ESG and CE results in recommendations for practice, improved alignment, and enhanced circular accountability for organisations with a focus on the environmental aspects of ESG.

3.1. Environmental, Social and Governance

ESG is a framework for businesses to consider the impact and dependencies on the environment and society, along with the quality of their corporate governance. It comprises all non-financial topics not typically covered by traditional financial reporting. It also provides a way to measure business risks and expose opportunities in those areas, for example, socially responsible investment (Weed, 2021). The E in ESG, environmental criteria, includes the energy, and the resources an organisation uses, the waste and emissions it produces in its production and operational process and the consequences for living beings as a result. E encompasses carbon emissions, climate change and environmental impact.

The S, the social criteria, addresses the relationships a company has and the reputation it fosters with people and institutions in the communities where it does business. S includes labour relations and diversity and inclusion. The G, governance, is the internal system of practices, controls, and procedures a company adopts to govern itself, make effective decisions, comply with the law, and meet moral and ethical demands of stakeholders.

There is a proliferation of studies on the effectiveness of ESG frameworks in Africa and Asia (e.g., Mgbame et al., 2020; Melinda & Wardhani, 2020), the Middle East (e.g., Al-

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Hiyari and Kolsi, 2021), Europe (e.g., La Rosa & Bernini, 2022), and America (e.g., Lisin et al., 2022). ESG ratings are often linked to socially responsible, environmental and governance metrics (Widyawati, 2020), which are "umbrella term for investment practices that target firms with "positive" social and environmental profiles" (Linnenluecke, 2022:2). Mutual fund companies, investment research firms, financial consultancies on responsible investment or accountancy, non-governmental organisations focused on responsible/ethical investment, and platforms focused either on sustainability investment or accountancy proliferate. ESG investing has evolved to meet the demands of institutional and retail investors, as well as certain public sector authorities, that wish to incorporate the impact of ESG factors on long-term financial risks and opportunities in their investment decision-making processes to generate long-term value. Carbon accounting, for example, is used to quantify and measure carbon emissions but also to help make informed decisions regarding mitigation strategies (Yanai et al., 2020) and is also used in the CE (Wang et al., 2019).

As with ESG, definitions of CE differ widely, with over a hundred definitions and uses reported (Kirchherr et al., 2023, 2017). This has implications as to how CE is viewed in ESG. CDP, for example, a charity that operates the international disclosure system for investors, municipalities, and commercial organisations, has multiple applications for scoring for the CE, with little consistency in applications². In other words, there seems to be a lack of consistent understanding and use of the concept of CE for ESG investment or accountancy (Alkaraan et al., 2023a, b). A commonly accepted and understood language to create synergy between CE and ESG is still underdeveloped (Walker, et al., 2021).

3.2 Circular Economy

According to the European Parliament (2023), the circular economy is a model of production and consumption, sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products if possible. This final phrase – 'if possible' – is a pragmatic acceptance that, whilst much of the literature assumes a closed loop and zero waste economy as the ideal goal (e.g., Kalmykova et al., 2018; Nußholz, 2018), limitations to the achievements of a circular economy are almost inevitable, at least within the context of our increasingly raw-material hungry, energy-inefficient, non-CO₂-capturing mainstream economy. Nevertheless, ESG asset managers are interested in CE because the umbrella term "sustainable production" requires an understanding of certain principles that are clearly articulated in circular or cradle-to-cradle (C2C) systems (McDonough & Braungart, 2010). C2C, which may be said to be one of the inspirations

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² <u>https://www.cdp.net</u>

or design principles underlying CE, identifies three key principles of alternative production systems: (a) waste equals food; (b) use current solar income, and (c) celebrate diversity.

Archetypes of circular business models emphasise non-economic value as a basis for competitive and collaborative advantage (Kopnina & Poldner, 2021). Value creation can expand from the "traditional areas" of different forms of "capital", namely financial, manufactured, intellectual, social, natural, and human, requiring both investment and accountancy systems (Hoang, 2018) that cause no harm to biodiversity, even if it is profitable to do so. This requires integrating biodiversity into financial decision-making (Nedopil, 2023), also in CE and ESG (Kopnina et al., 2024). CE promises to slow down the use of natural resources, reduce landscape and habitat disruption, help limit biodiversity loss and reduce greenhouse gas emissions (Alkaraan et al., 2023a, b). Designing out waste principles and closed-loop production systems, as well as C2C, offer ways to counter the dependency of production on the extraction of natural resources and wasteful production manufactured at poor quality or with a limited lifespan, in other words, with "built-in obsolescence" (Bulow, 1986). A CE aims to minimise or better eliminate the need for new natural resources by shifting from a "take-make-waste" production to a closed-loop industrial ecosystem (Kopnina & Bowden, 2023) or a system as close as possible to that. The design of modular products, which are more durable and at the end of their extended use can be re-utilised (Kopnina & Bowden, 2023) is one action perspective. It is through modularity that circular production can be geared toward reducing risks to biodiversity (Ruokamo et al., 2023), increasingly attracting the attention of ESG investors (Molin et al., 2022). However, this attention to biodiversity is often expressed indirectly, as in the current 10-R model.

A typical strategy in a CE involves value chain operators, small and medium-sized enterprises, multinationals, industry representatives, and governmental and non-governmental organisations (Lieder & Rashid, 2016; de Jesus & Mendonça, 2018; Geissdorfer et al., 2020). CE developed in various contexts with different motivations, some driven by the presence or absence of environmental regulation, others by the need for resource management in industrialised settings (Kopnina & Bowden, 2023).

In 2009, the CE Law Promotion mandated action at all levels of government and industry across China (Matthews & Tan, 2011; Su et al., 2013; McDowell et al., 2017). Place-based planning interventions (McDowell et al., 2017; Zhu et al., 2018) promoted co-industrial parks, incentivizing firms to reorient their process of production while fostering economic growth (Mathews & Tan, 2011; McDowell et al., 2017; Homrich et al., 2018; Yu et al., 2022).

In a parallel attempt, the European Commission (2015) has developed a policy titled "Closing the Loop: An EU Action Plan for the CE." This policy also concentrates on minimising the use of virgin natural resources and waste minimisation in each step of the value chain, whilst also supporting sustainable economic growth (Ghisellini et al., 2016; Domenech & Bahn-Walkowiak, 2019). The European policy is a hybrid approach, combining both top-down and bottom-up elements, in a sense of reliance on regulation and finance, including ESG, as incentives to nudge organisations towards 10-R activities (McDowell et al., 2017), and to change consumers into renters or users (Lazarevic & Valve, 2017). The European approach focuses on both strategic and operational levels, including the design of products, monitoring of processes, and safeguarding value (economic and other) beyond traditional corporate strategic management (Kopnina & Bowden, 2023). Sharing or collaborative economy, manufacturing relationships, location of operations, and customer-use payment models are offered as alternatives (Tukker, 2015; Kopnina & Poldner, 2021). However, the concept of CE is often linked to relative decoupling (Parrique et al., 2019). This suggests insufficient decoupling of economic growth from environmental pressures. Without meaningful decoupling, the claims of CE regarding ecosystem protection and biodiversity preservation become tenuous.

3.3 The updated 10-R Framework

The 10-R Framework categorises circularity strategies within the production chain along a spectrum from fully circular and, in principle, zero environmental impact, to fully linear and most environmentally destructive (Potting et al., 2017). This framework is a combination of the R-lists drawn up by Rli (2015) and Vermeulen et al. (2014). It is not by any means the only or most widely accepted or 'best' CE framework; it is, however, a highly cited way of conceptualising circularity and one that we have found useful in our work trying to bring CE and ESG together. This article offers an updated version of the 10-R framework that introduces Regenerate (which can include Rewilding and Restoration, e.g., creation of strictly protected conservation areas) being the most circular strategy.

To ensure the maintenance of planetary conditions that sustain life as we know it today, companies must change their operations by giving more than they take, rather than just reducing harm through reduction strategies such as efficiency increases. By shifting from a linear economic model to a circular one, companies and investors can change the focus from extraction to the regeneration of nature. Instead of degrading nature, regeneration strategies aim to build natural capital, allowing ecosystems to rebuild, increase biodiversity, and return biological materials to the earth's natural cycles (Ellen MacArthur Foundation, 2022). Before the industrial age, natural systems were capable of self-regeneration. Transitioning to a regenerative CE model enables relevant stakeholders to

aid the restoration and support of natural systems, maintaining positive reinforcing cycles of well-being between humans and wider nature (Buckton et al., 2023).

For these reasons, we introduce Regenerate as the prime circularity strategy, giving companies agency to set tangible goals. In our update, we also lowered the position of Reduce in the 10r-framework (from R3 to R5) compared to the version by Potting et.al. (2017). Reducing is an important strategy to slow down demand for the earth's finite resources. However, it is a 'less bad' solution to the traditional take, make and waste approaches, thus maintaining the status quo of unsustainable practices (Braungart, McDonough, 2010).



Figure 1. Updated circularity strategies within the production chain, adopted from Potting, et al. (2017).

We propose using the updated R-hierarchy model as a standard reporting unit for circular business models or funds within the ESG framework. The updated 10-R model as a reporting tool can help create a common language and understanding of what regeneration within CE entails in the context of ESG practices. The model could be expanded with a measurement and accounting for assessing its impact on ESG performance. However, it is vital to be explicit about the scope of what is being scored and avoid selective reporting. Recommended are separate analyses and scores ranging from large to smaller organisational units, depending on the line of business the organisation is active in, a company, or a branch, division, or department, and at the level of a process or a product. Another use is to benchmark the current situation in the market

and compare this with the aspirations of the organisation. In this way, the model can help to identify potential areas for improvement on multiple levels, thus improving the ESG performance. Using the updated R model can give investors a clear indication of their portfolio regarding CE performance to create more transparency (Lee, 2021).

3.4 The Circularity Scoring Model to Quantify Circularity Performance

Building on the work of Haas et al. (2015, 2020) and Mayer et al. (2019), the CSM has been developed as a proof of concept to quantify circularity through material and energy flow analysis used to determine the relative percentage of circular practices by companies or organisations as compared to their overall practice. The CSM integrates:

- Material flow analysis concepts,
- ESG-aligned sustainability metrics,
- Circularity principles across the updated R-hierarchy,
- And a focus on Scope 3 emissions and indirect impacts, recognising their often underreported yet substantial role in corporate footprints.

To provide a tangible link between the CE and the ESG framework, we recognise a need for more accurate and transparent reporting on sustainability performance for companies and organisations. Typically, scoring recommendations such as those formulated by the Taskforce on Nature-related Financial Disclosures (TNFD) and the Task Force on Climate-related Financial Disclosures (TCFD) are centred around a risk management approach to nature and climate. As has been illustrated by Sassanelli et al. (2019) in their comparative research on CE performance assessment methods, the measurement and assessment of circularity are not yet uniform in methodology, nor common practice in companies. Their work identifies a need for a holistic methodology which provides a set of Key Performance Indicators (KPI) "able to systematically and practically measure and assess the circularity degree of a given system and to take into account all the heterogeneous resources involved in its lifecycle" (Sassanelli et al., 2019, p. 449). As such, with the CSM, we propose a uniform model for scoring the level of circularity for companies and organisations irrespective of sector, industry, or geographical location, based on four key dimensions which influence the level of circularity for companies and organisations.

The CSM measures circularity based on the four key dimensions influencing CE and circularity of companies and organisations: 'Energy Consumption', 'Resource Extraction', 'Waste Prevention' and 'Regenerative Impact' as introduced below:

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- <u>Energy Consumption</u>. The production and consumption of non-renewable energy result directly in air pollution, climate change, water pollution, thermal pollution, and solid waste disposal. Regarding energy, circularity is measured as the percentage of renewable energy as part of total energy consumption by a company or organisation.
- <u>Resource Extraction</u>. Extraction of materials such as mining and deforestation results in destabilised soils, increased erosion, and reduced nutrient levels in terrestrial ecosystems and overall environmental degradation. Resource extraction is measured by the consumption of renewable materials and inputs as a percentage of the total material consumption by a company or organisation.
- <u>Waste Prevention</u>. Waste negatively impacts our environment due to contamination and pollution of air, soil and freshwater bodies, the squandering of finite resources, and the extinction of species. Regarding waste prevention, circularity is measured as the percentage of circular solutions in the company's product- and/or service design, packaging, handling and offering.
- <u>Regenerative Impact</u>. When shifting our economic activities from linear to circular, our focus shifts from resource extraction to ecosystem regeneration. An organisation's regenerative impact is measured as the percentage of the organisation's activities that support natural processes and help nature thrive.

The model follows the scope and differentiation that first appeared in the Greenhouse Gas Protocol (CHG, 2004). There, scope 1, 2 and 3 emissions are introduced, identifying three categories of emissions, highlighting the extended emissions impact of organisational activity. Scope 1 relates to emissions created by sources that are directly owned or controlled by a company or organisation. Scope 2 emissions are all indirect emissions, created through the generation of energy as consumed by that company or organisation. Scope 3 emissions are those that the company or organisation is indirectly responsible for, up and down its value chain. Scope 3 emissions typically form the largest part of the organisational emission footprint. For example, there are significant carbon emissions from the extraction, manufacture, and processing of raw materials. Instead of limiting the company's impact to the carbon footprint alone, the CSM expands the premise of scopes 1, 2 and 3 to the environmental impact, including, but not limited to, carbon emissions. As such, we generalise the scopes 1, 2 and 3 frameworks beyond carbon and energy accounting, to cover the broader environmental impacts of companies and organisations.

Specifically, this means that scope 1, 2, and 3 differentiation is applied not only to Energy Consumption but also to Resource Extraction, Waste Prevention, and Regenerative Impact. For Resource Extraction, scope 1 covers the consumption of renewable materials and inputs as a percentage of the total material consumption by company or organisation, while in scope 2 this consumption is expanded to indirect sources such as

providers of raw materials, inputs or services. Scope 3 addresses the level of resource extraction as part of the sources the company or organization is indirectly responsible for up and down its value chain. For Waste Prevention, scope 1 includes the circular solutions in a company or organization's product- and/or service design, its packaging, handling and offering to prevent direct waste generation on-site, where Scope 2 reflects waste prevention activities through purchased raw materials, inputs and services, and Scope 3 encompasses circular solutions for waste prevention in the related up- and down value chain. For Regenerative Impact, scope 1 relates to on-site regenerative practices such as soil restoration or habitat creation as a percentage of a company or organization's activities. Scope 2 accounts for regenerative effects of purchased materials, inputs or services, and Scope 3 includes regenerative initiatives adopted by supply chain partners or ecosystem restoration activities linked to supply chain choices. By applying this extended scope logic, the CSM ensures consistency across all dimensions of circular performance, creating a comprehensive view of both direct and indirect environmental impacts associated with organisational activities.

Regarding the scoring metrics as introduced above, for each of these four dimensions, we follow the findings of Ducoulombier (2021), Hertwich and Wood (2018), and Huang et al. (2009), all highlighting that value chain emissions and environmental impact (scope 3) make up the largest share of emissions for most organisations. Because of this, for each dimension, the CSM attributes 50 per cent of the possible circularity scoring points to the scope 3 activities of the company, as environmentally conscious strategies and decisions of a company in the value chain will yield the biggest impact. Through this, we hope to stimulate companies to become more actively involved in their respective value chains. For scope 1 and 2 activities, a maximum of 25 per cent of the total points for each of the respective four dimensions can be achived. Accountability within the CE practice is an unknown terrain, even though the concept of circularity is well-known (Kwarteng et al., 2023). Tools and frameworks to quantify circularity are therefore needed. Using scoring based on the above-listed four key dimensions, it becomes possible to quantify the level of circularity practices of an organisation or company, track circularity over time, and formulate goals based on its circularity scoring. The proposed CSM could also be used for inter-company comparison between the circularity scores of the respective four dimensions of the model. We hope that through the CSM accountability and visibility of circular practices and values will improve. Finally, we hope that the suggested quantification metrics for circular accountability and circularity scoring can become drivers for finance allocation through ESG and thereby a more CE.

Energy Consumption			Resource Extraction				
Percentage of renewable energy as part of total energy consumption by company or organisation			Consumption of renewable materials and inputs as a percentage of the total material consumption by company or organisation				
Scope 1	Scope 2	Scope 3	Scope 1	Scope 2	Scope 3		
Direct	Indirect	In value chain	Direct	Indirect	In value chain		
Enviro	nmental impact crea	ated by:	Environmental impact created by:				
sources that are	indirect sources	sources the	sources that are	indirect sources	sources the		
directly owned or	such as providers	company or	directly owned or	such as providers	company or		
controlled by the	of electricity used	organization is	controlled by the	of raw materials,	organisation is		
company or	by company or	indirectly	company or	inputs, or services	indirectly		
organisation	organisation	responsible for up	organisation	used by company	responsible for up		
		and down its value		or organisation	and down its value		
		chain			chain		
0 - 100% ¹	0 - 100% ²	0 - 100% ³	0 - 100% ¹	0 - 100% ²	0 - 100% ³		
Maximum Energy Cons	umption score: 100 poi	nts	Maximum Resource Ex	traction score: 100 point	ts		
¹ Score = % / 4	² Score = % / 4	³ Score = % / 2	¹ Score = % / 4	² Score = % / 4	³ Score = % / 2		
¹ Max. score: 25 pts.	² Max. score: 25 pts.	³ Max. score: 50 pts.	¹ Max. score: 25 pts.	² Max. score: 25 pts.	³ Max. score: 50 pts.		
Waste Prevention			Regenerative Impact				
Percentage of cir organisation's packag	cular solutions in product- and/or se ing, handling and	the company's or rvice design, its offering	The percentage of a company's or organisation's activities that support natural processes and helps nature thrive				
Coope 1 Coope 2 Coope 2			Scope 1	Scope 2	Scope 3		
Direct	Indirect	In value chain	Direct	Indirect	In value chain		
Enviro	nmental impact crea	ated by:	Environmental impact created by:				
sources that are	indirect sources	sources the	sources that are	indirect sources	sources the		
directly owned or	such as providers	company or	directly owned or	such as providers	company or		
controlled by the	of raw materials.	organisation is	controlled by the	of raw materials.	organisation is		
company or	inputs, or services	indirectly	company or	inputs, or services	indirectly		
organisation	used by company	responsible for up	organisation	used by company	responsible for up		
Ũ	or organisation	and down its value	Ŭ	or organisation	and down its value		
		chain			chain		
0 - 100%	0 - 100%2	0 - 100% ³	0 - 100%	0 - 100% ²	0 - 100% ³		
Maximum Waste Preve	ntion score: 100 points		Maximum Regenerative	e Impact score: 100 poin	ts		
¹ Score = % / 4	² Score = % / 4	³ Score = % / 2	¹ Score = % / 4	² Score = % / 4	³ Score = % / 2		
¹ Max. score: 25 pts.	² Max. score: 25 pts.	³ Max. score: 50 pts.	¹ Max. score: 25 pts.	² Max. score: 25 pts.	³ Max. score: 50 pts.		
Maximum total score on all four dimensions of Circularity Scoring Model: 400 points							

Figure 2. Circularity Scoring Model using qualitative and quantitative data from company sources.

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Case Illustration: Application of Circularity Scoring Model

To demonstrate the practical application of the CSM as a proof of concept, we used available data from the agribusiness sector. While not exhaustive, it highlights key quantifiable changes in circularity metrics resulting from targeted sustainability interventions. For this, the internal data of a Romanian company producing corn, barley, and wheat is used to provide a simplified illustration of the application of the CSM as the company undergoes operational and strategic changes.

The before and after of these changes illustrate the working of the CSM, illustrated by the scoring for all the four dimensions of the model: Energy Consumption, Resource Extraction, Waste Prevention, and Regenerative Impact.

Initial Operational Context

Initially, this company used diesel-powered tractors on its land, LNG for drying its produce after harvesting, solar panels for the lighting of buildings, and chemical fertilisers as production inputs. Rejected batches of produce were disposed of. In this situation, from the total Energy Consumption (electricity, diesel, and LNG), 40% of the energy production (solar panels) is renewable, resulting in a scope 1 score of 10 points (40/4). Sourced electricity (80% of total energy sourced) is qualified as green, but the LNG consumed (20% of total energy sourced) does not, resulting in a scope 2 score of 20 points (80/4). Information on energy consumption in its value chain is unknown, apart from one seed supplier, which uses renewable energy in its operations. Seeds sourced from this company amount to 4% of the Romanian company's costs, hence resulting in a score of 2 points (4/2) for scope 3. The total score for Energy Consumption for this Romanian company would hence be 32 from the possible 100 points (10+20+2). Regarding its **Resource Extraction**, the company has a scope 1 score of 0 points, as no direct material extraction or production activities are performed by the company itself; it relies entirely on external suppliers for its agricultural inputs. For scope 2, the indirect material impact from purchased inputs, specifically chemical fertilizers, is significant: 100% of the inputs are chemical fertilisers, also resulting in a score of 0 points. Regarding scope 3, no regenerative or recycled materials were present in the supply chain, thereby also scoring 0 points. The total initial score for Resource Extraction is thus 0 points (0+0+0) initially. The Waste Prevention scope 1 score is 0 points (0/4) as rejected produce is disposed of with no internal recycling or reuse. There is no external supplier-related waste reduction with the supplied chemical fertilisers, with upstream packaging and associated waste. No circular packaging or services, resulting in a scope 2 score of 0 points (0/4). Lastly, supplier packaging and post-consumer waste are not addressed at all, leaving the scope 3 score also 0 points (0/2). The total initial score for Waste Prevention is thus 0 points (0+0+0). The Regenerative Impact scope 1 score is 0 points (0/4), as the company initially does not implement any internal regenerative practices such as soil restoration, biodiversity enhancement, or ecosystem regeneration. There is no external purchase of regenerative materials or services, with chemical fertilisers and conventional energy still in use, resulting in a scope 2 score of 0 points (0/4). Lastly, the company's suppliers do not engage in regenerative practices or ecosystem restoration activities, leaving the scope 3 score also at 0 points (0/2). The total initial score for Regenerative Impact is thus 0 points (0+0+0). In this initial operational context, the total score according to the CSM amounts to 32 out of 400 points (32+0+0+0).

New Strategy and Impact

The Romanian company decided to invest in a composting facility with heat recovery. It now produces organic fertiliser based on locally sourced chicken manure and its earlier disposed rejected production batches, replacing 75% of previously used chemical fertilisers. The recovered heat is used for the drying of corn, barley, and wheat, completely offsetting the earlier LNG consumption. As such, the new Energy Consumption scope 1 score increases to a score of 15 points (60/4), as now the 20% LNG consumption has been offset with sustainably recovered process heat. Scope 2 score remains 20 points (80/4), and the scope 3 score remains 2 (4/2). The total new score for the Energy Consumption dimension then becomes 37 points out of 100 (15+20+2), signalling an increased percentage of renewable energy as part of total energy consumption. The new circularity score for **Resource Extraction** improves significantly because of the internal production of organic fertiliser. Scope 1, previously 0 points, now reflects direct input production from recycled biological material, achieving a score of 25 points (100/4) due to full allocation for internal regenerative material use. Scope 2 benefits as the reliance on externally sourced chemical fertilisers is reduced by 75%, resulting in a scope 2 score of 18.75 points (75/4). Scope 3 remains 0, as the upstream supply chain remains largely unchanged in terms of material circularity. The total improved Resource Extraction score is therefore 44.75 points (25+18.75+0). The new **Waste Prevention** score improves notably due to the internal recycling of previously discarded produce. Scope 1 score rises to 25 points (100/4), as 100% of previously disposed batches are now diverted from waste streams and used as input for composting. Scope 2 also improves to 18.75 points (75/4), reflecting reduced packaging and operational waste associated with decreased purchases (75%) of external chemical fertilisers. Scope 3 remains at 0 points, as supplier packaging waste and downstream waste have not yet been addressed. The total improved Waste Prevention score is therefore 43.75 points (25+18.75+0). Finally, the new Regenerative Impact score experiences meaningful improvements. Scope 1 score increases to 18.75 points (75/4), as the use of organic fertiliser (replacing 75% of chemical fertilizers) supports improved soil health and local biodiversity on the company's own farmland. As there are no new purchased services or materials that actively contribute to regenerative outcomes, the scope 2 score remains at 0 points. Scope 3 scoring also remains at 0 points, as upstream supplier practices have not shifted to regenerative models. The total improved Regenerative Impact score is therefore 18.75 points (18.75+0+0), bringing the total score to 144.25 out of 400 points.

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4. Towards a common language

Ideally, a CE approach places overcoming environmental problems centrally in economic planning and organisational strategy (Kopnina & Bowden, 2023). The business model innovation in CE is typically dependent on an initial design that enables reuse, recycling, and disassembly (Urbinati et al., 2017; Centobelli et al., 2020). In essence, CE promises to retain, reuse and/or recover materials, preserve biomass and energy, find nature-based solutions that do not threaten biodiversity and work to reduce the overall demand on natural resources while bettering our ecosystem and welfare (Kopnina et al., 2018; Kopnina & Poldner, 2021). As problems such as climate change, biodiversity loss and pollution are caused by increased consumption of non-renewable energy, land conversion, and rampant resource extraction and waste generation - all inconvenient truths for business operations (Panwar et al., 2023) – the overall impact of circularity should be absolute decoupling of economy from the use of (new) resources, which is very challenging in real life. Some of these frameworks and initiatives focus on CE but are without specifications and consensus as to how circularity is understood or measured. ESG-specific media groups like Environmental Finance³ have also been touching upon the subject of circularity (e.g., Cox, 2022), the use of the term varies in application and in organisations that account and invest in these companies based on assumed circularity without unambiguous metrics for circularity scoring and accountability.

4.1 Circularity and ESG Connections

As in the case of a collaborative economy, cooperation of various stakeholders within ESG systems is needed. On one side of the ethical and moral spectrum, there are investors' demands (commercial interests). On the other side, some investments seek only social (intertwined with environmental) returns (philanthropy).

ESG and CE requirements as part of public tenders are an example of this. Such capabilities can be split into evolutionary or radical business model innovation (Geissdoerfer et al., 2018b), with the former including holding stakeholder dialogues to support sustainability-related associations, inclusive of critical and disruptive stakeholders and technologies (Inigo et al., 2017). The activities constituting dynamic capabilities may develop over time as new circular prototype products and new circular business models may evolve, followed by business model execution, then changing industry expectations, and finally business model evolution and building credibility (Wade et al., 2022). These developments typically require an initial ESG investment, which in turn requires an understanding of the main circularity principles or hierarchies of needed action.

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³ <u>https://www.environmental-finance.com/</u>

	Philanthropy		Social Impact Investment		Sustainable	Conventional
					and	Financial
					Responsible	Investment
					Investment	
	Traditional	Venture	Social	Impact	ESG	Fully commercial
			investment	investment	investing	investment
Focus	Addresses	Addresses	Investment	Investment	Enhance	Limited or no
	societal	societal	with a focus	with an intent	long-term	regard to ESG
	challenges	challenges	on social	to have a	value by	
	through	with	and/or	measurable	using ESG	
	the	venture	environmental	environmental	factors to	
	provision	investment	outcome and	and/or social	mitigate risks	
	of grants	approaches	some expected	return.	and identify	
			financial		growth	
			return.		opportunities	
			Use of ESG m			
Return	Social	Social	Social return	Social return	Financial	Financial market
expectation	return only	return	and sub-	and adequate	market return	return only
		focussed	market	financial	focussed on	
			financial	market rate	long-term	
			return		value	

Table 1. The spectrum of social and financial investing is adapted from OECD (2019), based on earlier versions from various organisations.

However, it is not always clear as to what circularity gains are achieved due to the limited comparability of ESG studies across countries, at times the biased (against E of Environment) scoring metrics, the asset managers intentionally exaggerate or misrepresent sustainability characteristics in their products (Kolostyak, 2023). Sustainability gains might also be overshadowed by greenwashing, as well as "the aggregated nature of diverse environmental factors, different methodologies implemented by rating providers, and the lack of robust datasets have resulted in limited usefulness of environmental scoring as a tool for greening the financial sector" (Senadheera et al, 2021:2). Complicating the matters is the fact that while "virtue signalling" is becoming a widespread strategy of misleading investors (Kolostyak, 2023), large ESG fund managers, such as Stewart Investors, Liontrust Royal London, Schroder Asian Income, ticking a few boxes (Gard, 2021). The above make a case for scoring metrics such as the CSM introduced earlier. Also, there is emerging literature linking the

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ESG framework to circular production systems (Patil et al., 2021; Blinova et al., 2022; Montalbetti, 2022; Iliev et al., 2023). Ellen MacArthur Foundation pays lip service to ESGs' potential to work together with the CE, without specifying concrete connections:

"There is a growing recognition that ESG can not only identify risks but also deliver long-term growth and generate new sources of value by investing in players who are providing solutions and responses to the major challenges facing society... At the same time, governments, regulators, and central banks are reorienting public spending and policies towards the transition to an inclusive, low-carbon CE..." (Ellen MacArthur n.d.b).

The connection to nature-positive, biodiversity and ecosystem benefits of CE remains vague as well (Ellen MacArthur Foundation, n.d.b). Because Cradle to Cradle (C2C) challenges the take-make-waste production (McDonough & Braungart, 2010), the transformative potential of entire manufacturing is apparent, albeit poorly understood. Addressing this gap, this article surveys the general framework of circularity, based on C2C principles (McDonough & Braungart, 2010), and discusses the opportunities and limitations of applying the ESG framework to the CE.

4.2 Analysing circular systems in the context of ESG

Ideally, a circular system aims not just to increase the level of material and energy recovery but to eliminate the continuous need for the extraction of new and often scarce or finite resources, often an impossibility due to the laws of thermodynamics (De Man & Friege, 2016; Kopnina, 2021; Weed, 2022). As Josh Lepawsky (2022) noted, it is not possible to recycle energy continually (the second law of thermodynamics) without a loss in its quality or density, as no recycling plant can be run solely off the excess heat of another such recycling plant. Limited circularity can happen through dematerialisation, which requires the reorganisation of business through the transition from selling to leasing schemes (Savini, 2021; Stevens et al., 2021).

4.3 Greenwashing

Due to the fuzzy nature of defining the E in ESG and too easily branding products and processes circularly, greenwashing seems endemic in both systems (Kirchherr, 2022; Kopnina & Benkert, 2022). Circular frameworks can be subverted into the business-asusual model (Corvellec et al., 2022). Greenwashing involves using misleading information to gloss over bad behaviour or the misrepresentation of facts under the pretence of environmentally friendly practices and sustainability. Greenwashing refers to unsubstantiated claims aimed to deceive consumers into believing that a company's products are environmentally friendly. In addition, there are dilemmas for investors too.

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CE is not a domain of academic debate, but often a domain of practising (applied) academics or 'pracademics', receiving at least partial funding from corporate partners (Kirchherr, 2022). It is assumed that circularity is central to sustainable development, promising to marry a growth-centred economy (and corporate profit) with sustainability, which is questioned by critical authors (Kirchherr, 2022; Kopnina et al., 2024). A distinction between ideal, realistic, and subverted circular practice is helpful (Kirchherr et al., 2023, 2017). The companies that get certified as Cradle to Cradle or grace the Hall of Fame of the Ellen MacArthur Foundation rarely demonstrate products with infinite reuse (Bauwens, 2021; Kirchherr, 2022). Another concern is dubbed the "CE rebound" (Zink & Geyer, 2017), which underline the limitations of the very concept of circularity (Carus & Dammer, 2018; de Man & Friege, 2016; Holmes et al, 2021; Johansson & Henriksson, 2020; Kirchherr, 2022; Kopnina, 2021; Kopnina & Padfield, 2021). For example, in the food industry "waste is food" principle in the case of toilet waste is not the same in value as consumed products (Kopnina et al., 2023).

4.4 Strategic action linking ESG and CE

The implementation of CE is particularly challenging (e.g., Kalmykova et al., 2018), also due to the disconnect between business model innovation required for CE and drivers for finance allocation through ESG. Particularly dynamic capabilities, such as sensing, seizing, and reconfiguring (e.g., Marrucci et al., 2021), require different type of financial allocation to each activity. While there is a lot of research on "sustainable innovation" (e.g., Boons & Lüdeke-Freund 2013; Sehnem et al., 2022), few studies have attempted to analyse these capabilities concerning ESG.

ESG and CE initiatives can also come from private investments. Ideally, companies should become obliged or incentivised to disclose the proportion of waste and by-products that are redirected back into the production cycle or used for relevant purposes, for example, through scoring based on the proposed Circularity Scoring Model or the revised R framework. Also, this can:

- 1. Evoke confidence in ESG investments. Sustainability in both cases is seen as an engine for long-term business profitability: Customers, regulators and investor sentiment are changing in favour of more sustainable companies.
- 2. Stimulate sustainable businesses, as they will enjoy a lower cost of capital: Investors recognise that sustainable businesses offer lower risk and/or better long-term shareholder value. Businesses with poor ESG metrics or a lower score on the proposed Circularity Scoring Model will have higher costs of capital.
- 3. Result in safer working practices.

- 4. Result in reduced environmental harm and more environmentally sustainable practices.
- Reduce inequality through increased justice and fairness as building blocks of our society.
- Simulate collaboration to compete: Winning businesses will recognise they cannot improve their ESG footprint alone and will partner and collaborate across their value chain. The ability to manage partnerships and alliances_will become more important to all organisations.

4.5 Reflection of what remains unaccounted for

Bauwens (2021) postulates that one aspect missing from ESG and CE is the discussion of the limitations of economic growth and profit-oriented enterprises. For example, in food or clothes, dematerialization is almost impossible due to the laws of thermodynamics (material products, such as food, change in quality when consumed, e.g., become excrement). Some products, such as components of consumer electronics and cars, can be reused (for example, metals), despite the inevitable material loss due to wear and tear. Some products can be easily repaired or refurbished, but the process can be costly. ESG investment and CE strategies are still both geared toward the optimistic win-win scenarios in which value creation, particularly economic one, can be combined with other benefits without realising such limitations.

By implementing closed-loop production systems and regenerative design practices, companies can move beyond merely minimising their impact to actively contributing to ecological restoration. To ensure a comprehensive evaluation of their products' biodiversity and extinction impacts from the design and manufacturing phase to the end-of-life phase, companies should systematically evaluate and disclose product-life biodiversity impact due to e.g., their energy consumption, or the company's resource extraction practices, both directly, and in its value chain, as part of the ESG disclosure (Hassan et al., 2021; Anthony & Morrison-Saunders, 2023).

The proposed Circular Scoring Model aims to provide a means for measuring this and a company's ability to achieve waste prevention and have a regenerative impact. By evaluating and scoring their circular performance, companies can identify potential areas for improvement, such as renewable input materials for production, extending product lifespan, enhancing repairability, and using recycled and eco-friendly materials. Moreover, ESG disclosures could also include how companies prioritise sourcing materials locally and establish circular supply chains to address concerns about negative environmental consequences associated with transportation (Niu et al., 2020). This approach encourages conscious consumption, reduces the biodiversity footprint, supports local economies and

social welfare, and aims to resolve "wicked problems" (Guthrie & Dumay, 2021). Finally, an enhanced ESG framework can assist companies in evaluating their progress towards a degrowth economic model by prioritising ecological sustainability over excessive growth, as was argued in the case of CE (Hofmann, 2022). A few conditions must be met. First, the more restricted definitions and applications of CE need to be considered to avoid greenwashing. Thus, circularity in the sense of absolute decoupling of resource consumption from production, or the R of Refuse, or degrowth, and dematerialisation, needs to be prioritised as best practices in circularity. Following this, the E of ESG might need to be considered along the criteria of this stricter definition of CE, radically reducing production and consumption by switching to alternative business models. This radical reorientation would highlight that the E of Environment needs to be linked to accounting and investment opportunities in types of businesses and practices that would radically address severe problems such as biodiversity loss, ecosystem decline, as well as climate change.

5. Conclusion and Recommendations

This article has addressed the relationship between ESG criteria and CE and explored some systems of ESG reporting, rating, prioritising investments, and the impact of business strategy decisions on CE and vice versa. We believe that the outcomes of our work underscore the need for further empirical studies to test the application of the proposed frameworks. Additionally, the integration of biodiversity-focused principles within CE calls for a deeper exploration of how organizations can operationalize regeneration and rewilding in their sustainability strategies. This methodology establishes a strong foundation for advancing theoretical and practical understanding of the relationship between CE and ESG, emphasizing their potential to enhance corporate accountability and sustainability outcomes.

In response to the first research question regarding the ESG framework and its influence on the adoption and success of circular economy practices, we have made explicit how the CE framework can invigorate the practice of ESG and proposed means for qualitative scoring circular practices and quantitative substantiation of CE efforts. We have established that linking CE principles through both accounting and investment practices can help to identify potential areas for improvement, such as a shift to renewable sources of energy, alternative input materials for production, extending product lifespan, enhancing repairability, reducing waste, using recycled and eco-friendly materials, and increased regenerative impact.

Concerning the second research question about the tools and metrics to measure and integrate circularity into ESG criteria, we propose a qualitative scoring for assessing CE

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impact on current and future ESG performance based on the updated 10-R model combined with quantitative substantiation of CE efforts via the Circular Scoring Model, contributing to existing systems of ESG reporting, rating, and prioritising investments' impact upon CE and vice versa.

These models aim to inform organisations and managers about planning, measuring, forecasting, innovating, or weighing opportunities or threats relating to sustainability. We have also identified some potential pitfalls or bottlenecks, especially concerning greenwashing in both ESG and CE. As with ESG, definitions of CE differ widely, with the apparent danger of greenwashing and selective reporting on corporate success stories that may give investors and society false positive impressions. Linking stricter definitions (absolute decoupling of resource consumption from economic activity, restricting production and consumption, or the R of Refuse) of CE and a more restricted part of E of ESG (focusing on biodiversity loss mitigation measures), can help to address these issues.

In response to the third research question about the alignment of CE and ESG frameworks to inform better decision-making and foster accountability, we have argued that CE standards and practices have the potential to make the ESG framework more actionable and accountable and that ESG frameworks can make CE approaches more rigorous. We suggest connecting CE principles through both accounting and investment practices can help to identify potential areas for improvement, such as a shift to renewable energy, alternative input materials for production, extending product lifespan, enhancing repairability, reducing waste, using recycled and eco-friendly materials, and increasing regenerative impact. The qualitative reporting on CE themes via the updated 10-R (with 11-Rs including Regeneration) framework can provide companies with a clear, relevant, and biodiversity action-orientated conceptualisation of CE. Subsequent highlighting of E for ecosystems of ESG promises to make the connection between ESGs and CE practice more explicit and accountable. Doing so can help companies and investors to create a common language and give companies an easy-to-understand and implement means to improve non-financial reporting, find business opportunities, and increase the level of circularity. The proposed Circularity Scoring Model can serve to both demystify and quantify the circular performance of companies and organisations. In addition to optimising the use of existing ESG reporting tools, ratings, and metrics, using the CSM as an accountability and reporting tool provides a clear and tangible link between the CE and the ESG framework that could enhance non-financial reporting and help companies make informed, long-term sustainable business decisions.

We invite academics, practitioners, and (audit) companies to expand on the updated version of the 10-R framework and the proposed Circularity Scoring Model. The development of rankings based on circularity scores, and enabling benchmarking metrics

using a company's circularity performance as quantified through the CSM can contribute to the establishment of circular standards and measurement systems.

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Cocoa shell bioplastic: a circular path towards sustainability

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Keywords: bioplastic synthesis; agricultural waste; sustainability; circular economy; biodegradability.

Abstract. This study explored the potential of cocoa shells as a sustainable feedstock for bioplastic production. Two treatments, T1 and T2, using a mixture of cocoa shell flour and cassava starch, were evaluated based on their filtration, solubility, elongation, strength, moisture content, and biodegradability. The results showed that the cocoa shell flour had favorable



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rheological and thermal properties (viscosity: 39 mPa s; gelatinization temperature: 80°C), though it had high moisture (24.94%) and ash content (23.93%). Treatment T2 demonstrated superior filtration and solubility, while T1 excelled in elongation, strength, and biodegradability. Both treatments showed good solubility, indicating potential compatibility with different solvents. These findings suggest that cocoa shells are a promising and eco-friendly resource for bioplastic production.

1. Introduction

Agro-food waste, a significant by-product of agribusiness, holds immense untapped potential for resource recovery and sustainable innovation. As noted by Matei et al. (2021), this waste stream offers valuable opportunities across various sectors. While traditionally used primarily as animal feed, recent studies, such as those by Caliceti et al. (2022), have demonstrated its wider applicability in multiple industries. Agro-food by-products like peels, pomace, seeds, and leaves are rich in bioactive compounds, including phenols, anthocyanins, peptides, and fatty acids. These by-products also contain valuable fibers and enzymes, making them ideal for applications in functional foods, pharmaceuticals, and cosmetics (Del Río et al., 2021). This combination of bioactive components and structural elements positions agro-food waste as a promising and versatile raw material for diverse industrial uses (Atiwesh et al., 2021).

The cocoa industry exemplifies the significant economic and environmental losses caused by inefficient management of agri-food waste (Torres, 2023). Parra et al. (2018) emphasize the vast amounts of waste produced in this sector, representing a missed opportunity for resource recovery. In Ecuador alone, around 700,000 tons of cocoa waste are generated annually, with only 10% of the cocoa fruit being utilized (Romero, 2020). Key by-products, such as mucilage, which is rich in pectin, and cocoa pods, are frequently discarded in large quantities, contributing to soil degradation and increasing the risk of disease (Plasencia et al., 2021). This highlights the need for more sustainable practices in the cocoa industry to capitalize on these underutilized resources.

The environmental challenges posed by plastic waste underscore the urgent need for sustainable waste management solutions. The widespread production of conventional plastics has caused severe environmental harm, with vast amounts of plastic waste accumulating and disrupting ecosystems and wildlife. Globally, around 100 million tons of plastic are produced each year, with 25 million tons consisting of unnecessary items that directly contribute to pollution (Barrientos, 2019; Ospina, 2019). This highlights the critical importance of reducing plastic waste and adopting eco-friendlier alternatives to mitigate further environmental damage.

Bioplastics, made from plant-based materials, provide a sustainable alternative to conventional plastics, offering significant environmental benefits and with significant potential for recovery of bio-based plastics at end-of-life (Ritzen et al., 2023). Their biodegradable nature helps address the growing issue of agri-food waste, particularly in the cocoa industry. By utilizing cocoa by-products for bioplastic production, we can reduce dependence on traditional plastics, lessen environmental harm, and promote more sustainable practices. Bioplastics have the potential to lower the environmental footprint of plastic production and disposal by decreasing greenhouse gas emissions, reducing reliance on fossil fuels, and encouraging greener industrial processes. Moreover, bioplastics can play an important role in building resilient infrastructure and fostering innovation. The development of bioplastics from renewable resources marks a vital step toward resource-efficient technologies that drive sustainability and promote a circular economy (Rosenboom et al., 2022).

Agricultural waste is increasingly recognized as an ideal feedstock for bioplastic production due to its high content of cellulose, pectin, and starch, which make it highly suitable for conversion into bioplastics. This approach not only addresses waste disposal challenges but also mitigates its negative effects on soil and water resources (Choudhary et al., 2024). The present study focuses on the utilization of cocoa shells for bioplastic synthesis, beginning with a detailed characterization of their properties. This analysis will guide the development of precise experimental procedures to create a safe, sustainable bioplastic by-product, contributing to environmental sustainability and advancing a more efficient circular economy.

This study adds to the scientific community by providing a new avenue for bioplastic development from cocoa shells. It also offers practical insights into formulating bioplastics with enhanced properties by mixing cocoa shell flour with cassava starch. Such research helps advance the field of green materials science, particularly in terms of resource utilization and sets the stage for further

research into improving and scaling bioplastic formulations for commercial applications.

2. Methodology

The research was conducted in three sequential phases: first, the extraction of cocoa shell flour; second, the development of the bioplastic; and third, the statistical analysis of the material's resulting properties. Each phase was designed to systematically assess the potential of cocoa shell flour as a viable feedstock for bioplastic production. This study adapted several methods from prior research to align with its objectives. Notably, the work of Jõgi & Bhat (2020), which outlines the direct extraction of bioplastics from biomass, informed this investigation development. For sample collection and pre-treatment, the methodology followed Azmin et al. (2020) and other relevant studies, as detailed below.

2.1. Obtaining cocoa shell flour

Organic cocoa shells, specifically from fine aroma Nacional cocoa, were sourced as raw material from the Fortaleza del Valle Association, a renowned farmers' collective in Calceta, Manabí Province, Ecuador, known for its commitment to organic farming. The cocoa shells used for flour production were directly obtained from this association, ensuring high-quality, organically grown materials.

Flour extraction followed the wet method described by Herrera et al. (2020). Three kilograms of cocoa shells were initially reduced in size and ground to form a liquid suspension. This suspension was then filtered and allowed to settle for 24 hours to isolate the flour.

Physicochemical characterization was performed according to Cando (2021), assessing key parameters such as density, viscosity, pH, gelatinization temperature, moisture content, dry matter, water absorption index, water solubility index, swelling power, and ash content, the latter determined by calcination.

2.2. Bioplastics production process

Bioplastics were synthesized using a mixture of 2 g of cocoa shell flour and cassava starch, following a completely randomized experimental design. Building on the methodology of Lizinka (2022), two levels of cassava starch (5% and 10%)

and three stirring times (5, 10, and 15 minutes) were evaluated. The bioplastics were prepared using the casting technique, where 10 g of each solid were mixed in 100 ml of distilled water. The mixture was stirred at 500 rpm for the specified times and then gelatinized at 70°C for 30 minutes. To enhance flexibility, 3 ml of glycerin and 1 ml of acetic acid were added as plasticizers, resulting in a viscous solution that was molded into bioplastic sheets.

The bioplastic mixture was poured into Petri dishes and dried in an oven at 35°C for 24 hours. Subsequent analyses, including tests for tensile strength, water filtration (resistance), elongation, and solubility, were performed in accordance with the methods outlined by Cedeño & Gilces (2022).

Moisture content was measured by first weighing the sample, then drying it in an oven at 105°C for 24 hours and reweighing it. This process was repeated until a constant weight was achieved. The moisture content was calculated using the method described by Azmin et al. (2020):

$$Moisture(\%) = \frac{(w - w_t)}{w} * 100$$

where w is the initial weight of the bioplastic, and w_t is the final weight or constant dry weight of the bioplastic.

To assess biodegradability, bioplastic films with an initial weight (Wo) were buried at a depth of 3.5 cm in moist humus soil within a glass container. The samples were retrieved after 2, 4, 6, 8, and 10 days, cleaned of any adhering soil particles, and dried at 105°C for 3 hours to determine their final weight (Wt). The percentage of weight loss (%WL) was then calculated using the method outlined by Sernaqué et al. (2020):

$$WL(\%) = \frac{(W_0 - W_t)}{W_0} * 100$$

2.3. Statistical analysis

To evaluate whether significant differences existed between treatment means, an ANOVA was conducted. Post-hoc tests were employed to identify specific mean differences. Before analysis, the assumptions of normality and homogeneity of variance for the ANOVA were assessed using the Shapiro-Wilk test. In instances of non-normality, the non-parametric Kruskal-Wallis test was utilized. To examine correlations between variables, Pearson correlation coefficients were

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calculated for normally distributed data, while Spearman correlation coefficients were used for non-normally distributed data.

3. Results and discussion

3.1. Characterization of cocoa shell-based flour

The process of obtaining cocoa shell flour from 7 kg of fine aroma domestic cocoa resulted in 700 g of flour through wet extraction, yielding 10%. In contrast, Muñoz et al. (2020) reported a higher yield of 29.08% using a drying and grinding method for cocoa shells. The disparity in yields may be attributed to differences in processing techniques and material conditions. Additionally, the chemical analysis conducted by Muñoz et al. (2020) revealed a crude fiber content of 26.75% and carbohydrates comprising 52.61%, highlighting the potential of cocoa shells as a valuable agro-industrial by-product.

The pH measurement yielded a result of 8.13, indicating that the product derived from the cocoa shell is slightly alkaline, which suggests areas for improvement. In contrast, Guamán's study (2022) on bioplastics made from triticale starch and rice husk reported a pH range of 5.42 to 5.51, classified as slightly acidic. This acidic range is advantageous for the stability and mechanical properties of bioplastics, emphasizing the importance of optimizing the pH of our products to enhance their functional characteristics.

The apparent density analysis revealed that the cocoa shell flour demonstrates significant cohesion and uniformity, with a loose density of 0.35 g/ml and a compacted density of 0.40 g/ml. These values, while slightly lower, are comparable to those reported by Martínez (2023), who found a density of 0.398 g/ml. This suggests that the cocoa shell flour has an average density that falls within the typical range for similar materials.

The rheological properties of the cocoa shell flour revealed a gelatinization temperature of 80 °C and a viscosity of 39 mPa·s. This low viscosity, in comparison to other biopolymers such as cassava and potato starch (Vélez et al., 2021), suggests a reduced resistance to flow. This characteristic may be attributed to the flour's unique composition, which could feature a lower amylose content or a higher proportion of fibrous components. The low viscosity may be advantageous for applications that require greater fluidity, such as formulating food products with a smooth texture or in industrial processes involving pumping and mixing.

Cocoa shell flour, which is rich in native starch, exhibited a water absorption index of 6.75 g/g, slightly higher than the average reported for cocoa shell starchbased bionanocomposites (Noraini et al., 2024). The water solubility of 5.83% and swelling power of 6.9 indicate a moderate interaction with water, which may limit its application in humid environments. These findings align with the general trend observed in starch-based bioplastics, which often exhibit high humidity sensitivity and suboptimal mechanical properties (Oluwasina et al., 2021). However, through chemical modification or the incorporation of reinforcements, it is possible to significantly enhance these properties, thereby broadening the potential applications of this biomaterial.

The moisture content of cocoa shell flour was measured at 24.94%, which is significantly higher than that reported for bioplastic films based on dialdehyde starch (Oluwasina et al., 2021). This elevated moisture level can adversely affect the mechanical properties and stability of the material, promoting microbial growth and degradation. In contrast, the dry matter was calculated at 75.06%, indicating a substantial solid content (Noraini et al., 2024). However, the high ash content of 23.93% suggests a significant concentration of inorganic minerals, which may influence the functional properties of the material. Comparing these findings with those reported by Ramadhan & Handayani (2020) for breadfruit starch, which showed an ash content of only 1.08%, highlights a notable difference that could be attributed to the inherent characteristics of the raw material, as well as the extraction and purification processes employed.

3.2. Bioplastic production process

As shown in Table 1, the bioplastic samples from treatments T1 and T2 exhibited a slightly rough or fibrous texture, characteristic of cocoa shell material. While T1 displayed a more pronounced pigmented brown color, both treatments demonstrated a comparable overall hue. The dried bioplastic samples had a hard and dry texture, reflecting the intrinsic properties of the cocoa shell.

The color of the bioplastic serves as a visual indicator of its cellulose content, with darker shades indicating a higher proportion of cellulose (Azmin et al., 2020). In contrast, bioplastics with lower cellulose concentrations tend to be drier and harder than those with higher cellulose content (Maulida & Maysarah, 2020). Additionally, the presence of cellulose contributes to increased moisture content in the bioplastic, with 100% cellulose bioplastics exhibiting the highest moisture levels (Bhatia et al., 2021). Cellulosic materials naturally absorb and release moisture from their surrounding environment until they reach a state of equilibrium (Wang et al., 2018).

 Table 1. Sensory evaluation of the bioplastic film: color, texture, odor and physical properties.

Treatment	Color	Texture	Smell	Physical appearance
T1	Pigmented brown	Dry, hard	Odorless	
T2	Pigmented brown	Dry, hard	Odorless	T2

Based on the results of the Shapiro-Wilk test, ANOVA was conducted for filtration and solubility, as these variables met the assumption of normality (Table 2). For the remaining variables—moisture, elongation, and strength—which exhibited deviations from normality, the non-parametric Kruskal-Wallis test was employed.

Variable	n	Mean	SD	W*	p (one tail)
Filtration	6	614.67	255.36	0.86	0.2535
Humidity	6	13.33	1.86	0.75	0.0229
Solubility	6	66.11	3.87	0.82	0.1096
Elongation	6	8.49	2.64	0.67	0.0020
Endurance	6	27.00	5.21	0.76	0.0251

Table 2. Shapiro-Wilk test for assessment of normality.

Although no statistically significant differences in water resistance (measured as filtration) were observed between the bioplastic treatments, T2 demonstrated a slightly higher filtration value of 697.00 mL compared to 532.33 mL for T1, as illustrated in Figure 1. This finding suggests that T2 may possess a marginally

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more porous or permeable structure, which could influence its barrier properties and potential applications.



Figure 1. Comparison of filtration values between treatment groups.

While both T1 and T2 displayed reasonable solubility, T2's slight edge might be beneficial in specific applications where solvent compatibility is a critical factor. Further investigation into the underlying reasons for this difference could inform future formulation and optimization efforts.

While no statistical differences were found, T1 consistently outperformed T2 in elongation, strength, and moisture. This suggests a potentially more robust and resilient structure, making T1 better suited for applications demanding higher mechanical performance. Specifically, T1 exhibited an elongation of 10.90%, strength of 31.71%, and higher moisture content of 14.00%, while T2 recorded 6.07%, 22.30%, and 12.67%, respectively (Table 3).

While high moisture content can promote microbial growth and affect the appearance and mechanical properties of the bioplastic (Macêdo et al., 2022), T2 with a moisture content of 12.67% offers a balance between reducing the risk of mold and maintaining microbial activity. This is supported by Azmin et al. (2020),

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who found a minimum moisture content of 8.01% in cocoa shell bioplastic with 25% cellulose.



Figure 2. Comparison of solubility values between treatment groups.

Table 3. Kruskal-Wallis test for comparative analysis of elongation, strength and humidity.

Variable	Treatment	Ν	Means	SD	Medians	н	р
Elongation	1	3	10.90	0.06	10.90	3.86	0.1000
Elongation	2	3	6.07	0.08	6.12		
Endurance	1	3	31.71	1.13	32.12	3.86	0.1000
Endurance	2	3	22.30	0.51	22.56		
Humidity	1	3	14.00	1.73	15.00	0.76	0.7000
Humidity	2	3	12.67	2.08	12.00		

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Furthermore, studies have shown a correlation between cellulose concentration and moisture content in bioplastics, with lower cellulose levels resulting in lower moisture uptake (Azmin et al., 2020). In a previous study, Zambrano et al. (2022) produced a bioplastic film from Eichhornia crassipes with a moisture content of 19%. Additionally, increasing the glycerin content of bioplastics has been shown to improve tensile strength. Scanning electron microscopy analysis has revealed that bioplastic films containing 5% glycerin exhibit a more uniform and homogeneous texture (Gallegos-Carrillo et al., 2024).

Elongation, a measure of a bioplastic's flexibility, is crucial for applications requiring flexibility or impact resistance (Budiman et al., 2022). Among the bioplastics tested, T1 demonstrated superior elongation properties, reaching 10.90%. This value significantly exceeded the 3.068% reported by Syuhada et al. (2020) for cassava peel bioplastic and the 6.8% reported by Lestari et al. (2020) for jackfruit seed and rice bioplastics. However, it fell short of the 26.67% achieved by Handayani et al. (2023) using durian seed starch.

The achievement of 31.71% strength by T1 bioplastic represents a significant breakthrough in sustainable materials development. This level of strength indicates the bioplastic's ability to withstand substantial force or stress before breaking or deforming (Oliva & Encinas, 2021). This property is crucial for its potential applications in packaging, automotive parts, and consumer products, demonstrating its potential to enhance durability and performance in these fields (Dawam et al., 2020).

Conversely, T1 exhibited a higher biodegradation rate than T2, with a classification of 77% compared to 64% (Figure 3). These findings suggest that T1 may have a more favorable biodegradation profile, although no statistically significant difference was observed (Table 4). The biodegradability of bioplastics depends on the physicochemical structure of the polymer (Jõgi & Bhat, 2020).

As acetic acid content was the only differentiating factor between treatments, the observed differences in bioplastic properties can be attributed to the influence of acetic acid. While T2 demonstrated superior filtration, solubility, and moisture, T1 exhibited advantages in elongation, strength, and biodegradability. A lower concentration of acetic acid in T1 likely resulted in reduced cross-linking, leading to better flexibility, moisture absorption, and potentially improved biodegradability.

Correlation analysis revealed a moderate positive correlation between filtration and acetic acid (r = 0.35, p < 0.001), suggesting that both variables increase together. However, a very weak positive correlation was found between acetic

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acid and solubility (r = 0.21, p = 0.6953), which was not statistically significant. Conversely, a moderate to strong negative correlation was observed between acetic acid and elongation (r = -0.88, p = 0.0213) and strength (r = -0.88, p = 0.0213), indicating that as acetic acid increases, these two variables tend to decrease. While acetic acid and moisture showed a weak negative correlation (r = -0.42, p = 0.4050), it was not statistically significant.

Table 4. Shapiro-Wilk test for the evaluation of the normality of biodegradability.

Variał	ole	n	Mean	SD	W*	P (one tail)
Biodegradability		36	70,00	0.17	0.96	0.5248
Biodegradability (%)	82 77 - 72 - 67 -	36	70,00	0.17	0.96	0.5248
	63		1	2	В	
			Trea	tment		

Figure 3. Biodegradation rates of bioplastic samples by treatment.

Acetic acid plays a crucial role in cross-linking the bioplastic structure (Poon et al., 2024). Cross-linking is a chemical reaction that forms bonds between polymer chains, affecting properties such as strength, flexibility, and biodegradability (Bello et al., 2024). The acidic nature of acetic acid could catalyze other reactions

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between cellulose and other bioplastic components like lignin or hemicellulose, further influencing cross-linking and material properties (Syarif et al., 2022). However, further research is needed to fully elucidate the complex relationship between acetic acid content and bioplastic properties.

Avellán et al. (2020) achieved 89.40% biodegradability after 42 days for corn flour bioplastic. During the bioplastic degradation process, it was observed that a higher glycerin content during bioplastic manufacture correlated with increased degradability. Glycerol's plasticizing effect stems from its ability to reduce intermolecular forces within the flour, thereby decreasing sheet strength. This reduction is due to glycerol's ability to disrupt internal hydrogen bonds (Sernaqué et al., 2020).

4. Conclusions

Bioplastics, made entirely from renewable biological resources, are increasingly recognized as a critical component of a sustainable future. With an annual production of approximately 2 million tonnes, bioplastics offer a promising alternative to conventional, fossil-based plastics (Di Bartolo et al., 2021). These materials contribute to reducing fossil fuel dependency, promoting recycling and biodegradable alternatives, and limiting the use of harmful chemicals in manufacturing processes. Countries such as Japan, Malaysia, Singapore, and South Korea have implemented financial incentives to support the development and adoption of bioplastics (Rosenboom et al., 2022).

Although the bioplastics industry remains small in comparison to conventional plastic production, which reached 360 million tonnes in 2018, it is projected to grow substantially, with an anticipated 40% increase in production over the next five years (Di Bartolo et al., 2021). This growth aligns with the principles of the circular economy, which focuses on minimizing waste and maximizing resource efficiency (Merchan et al., 2022). By using agricultural and food waste as raw materials, the bioplastics industry supports a closed-loop system where materials are continuously recycled and repurposed (Visco et al., 2022). This strategy not only reduces waste but also creates valuable products like bioplastics with characteristics that can further advance sustainable circular bioeconomy goals (Abina et al., 2023; Foschi, et al., 2023).

Our research shows the potential of cocoa shells for bioplastic production. Cocoa shell flour, an agro-industrial by-product, shows significant potential for creating sustainable materials. Despite its high moisture (24.94%) and ash

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(23.9275%) content, its rheological and thermal properties, such as low viscosity (39 mPa s) and gelatinization temperature of 80 °C, position it as a promising raw material for various applications. Results from T1 and T2 treatments for obtaining bioplastics demonstrate the flour's versatility. T2 showed a slightly higher filtration value (697.00 mL) compared to T1 (532.33 mL), and for solubility, T2 had a marginal advantage with an average of 66.83% versus T1's 65.38%. While both treatments showed reasonable solubility, T2 might be slightly more suitable for specific solvents or conditions. Conversely, T1 exhibited higher elongation (10.90%), strength (31.71%), and moisture content (14.00%) compared to T2's values of 6.07%, 22.30%, and 12.67%, respectively. Furthermore, T1 had a higher biodegradation rate of 77% versus T2's 64%. Overall, T2 excelled in filtration, solubility, and moisture content, while T1 offered better elongation, strength, and biodegradability.

However, several areas for improvement remain. One key limitation is the extraction and processing of cocoa shell flour, which could be optimized to enhance both the efficiency of the process and the quality of the bioplastic produced. Alternative extraction methods, such as using enzymatic or green solvent techniques, could help improve the yield and properties of the cocoa shell-derived material. Additionally, this study was constrained to only two treatments due to limited financial resources. Future research should expand on this by including more treatments and testing different ratios or combinations of cocoa shell flour with other biodegradable materials, which would provide a broader understanding of how various formulations affect bioplastic performance.

Moreover, future studies could focus on using cocoa shell starch instead of flour as the base material, as starch may offer improved mechanical and thermal properties for bioplastic production, depending on the treatment process. Exploring the feasibility of starch extraction from cocoa shells could open new possibilities for enhancing the material's performance. Additionally, comparative studies with other agricultural waste materials could highlight the relative advantages of cocoa shells in bioplastic applications. Finally, scaling up production and assessing the economic viability of using cocoa shells in largescale bioplastic manufacturing would be crucial for determining their commercial potential and environmental benefits.

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Enhancing compost quality with *bacillus* bacteria Leveraging cocoa shells and banana pseudostems

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- 1. Introduction
- 2. Methodology
- 3. Results and discussion
- 4. Conclusions

Keywords: pollution; phytotoxicity; agricultural waste; environmental management.

Abstract. Agricultural waste pollutes natural resources, impacting soil fertility, biodiversity, and CO2 levels. Composting offers an alternative solution. This study evaluated Bacillus albus and Bacillus wiedmannii for composting banana pseudostem and cocoa shell waste. The experiment, divided into 4 treatments, found both residues to be slightly acidic. The pseudostem had higher moisture content (30.5%) compared to the cocoa shell (12.3%). During composting, temperature peaked at 33.7°C and ended at 25.5°C, with a final pH of 7.4 and moisture of 42%. Using statistical



analysis, treatments T3 (cocoa shell/B. wiedmannii) and T4 displayed the best results for various parameters. Additionally, T4 showed significant improvement in NPK content. Germination and root growth tests with cucumber seeds revealed no phytotoxicity, highlighting the effectiveness of composting for waste management and its potential use in agriculture.

1. Introduction

Every agricultural activity generates substantial unused waste. Studies by Sánchez et al. (2019); Salgado (2020) suggest that in developing countries, approximately 80% of this waste is burned, while only a small fraction is used productively. This mismanagement, as highlighted by Velastegui et al. (2017), leads to soil and water contamination, along with the proliferation of bacteria and diseases.

Composting offers a viable alternative to manage agricultural waste. Banana stems and cocoa shells, for example, can be transformed into nutrient-rich compost through controlled decomposition (Pérez, 2020). This not only fertilizes the soil but also promotes overall environmental sustainability. In Ecuador, banana cultivation generates significant waste, with Segarra (2022) estimating a yearly total of approximately 12,402,620.44 tons.

According to Silva et al. (2021), Ecuador's banana production is concentrated in the province of Manabí, making it the country's leader in both banana stem waste and cocoa residue. Manabí, along with Guayas, Los Ríos, Esmeraldas, Santa Elena, and El Oro, are the main cocoa producers (Silva et al., 2021).

Condori (2022) suggests that adding efficient microorganisms like *Bacillus spp.* and subtilis can accelerate composting, reduce unpleasant odors, and increase nutrient availability. These bacteria, as described by Moncayo (2021), secrete proteins and metabolites that benefit plants by counteracting pests and diseases, promoting development, fixing nitrogen, and synthesizing phytohormones for root growth (Bonilla et al., 2021).

This research aims to analyze the effect of Bacillus bacteria on the quality of compost derived from agricultural waste (banana *pseudostem* and cocoa shell). Our goal is to contribute to environmental care by promoting sustainable agriculture through the efficient utilization of organic waste. This aligns with the provisions of Chapter 83, Item 6 of the Constitution of Ecuador, which emphasizes the

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responsibility of Ecuadorians to "respect the rights of nature, preserve a healthy environment, and use natural resources rationally, sustainably, and permanently."

2. Methodology

The research was conducted at the Organic Fertilizers Unit (Orchidarium) of the Environmental Engineering career in Escuela Superior Politécnica Agropecuaria de Manabí Manuel Félix López (ESPAM MFL). The unit is situated on the El Limón site, located in the Calceta parish, Manabí province. The specific coordinates are UTM WGS 84: 0°49'28" South latitude and 80°10'54" West longitude (Figure 1). This research employs a combined experimental and

bibliographic approach (Ramos, 2021; Arellano, 2023).



Figure 1. Location of research site.

Experimental design

A two-factor completely randomized design (DCA) was employed for this experiment (Delgado & García, 2023). The research was conducted in a semicontrolled environment with consistent starting materials. Four treatments were established, representing all possible combinations of factor levels (Table 1). Each treatment was replicated four times, resulting in a total of 16 experimental

units. Data analysis followed established statistical methods, including analysis of variance (ANOVA) with a 5% significance level and Tukey's HSD test for multiple comparisons of means (Delgado & García, 2023).

Treatments	Agricultural residuals	Bacteria
T 1	<u>Banana pseudostem</u>	<u>B. wiedmannii (Miller et al., 2016)</u>
Τ 2	<u>Banana pseudostem</u>	<u>B. albus (Solano–Bastida, 2023)</u>
Τ ₃	<u>Cocoa shell</u>	<u>B. wiedmannii</u>
Τ ₄	<u>Cocoa shell</u>	<u>B. albus</u>
Repetitions	<u>4</u>	
Quantity of manure x EU	<u>13kg</u>	
Amount of agricultural waste x EU	<u>13kg</u>	

Table 1. Combination of levels and factors.

Composting setup

Each treatment was conducted in a dedicated 40-liter plastic tub. The tubs were filled with a total of 13 kg of waste, with a 50:50 ratio of banana *pseudostem* and cocoa shell (by weight). This balanced composition was chosen because, according to Herrera (2022), incorporating dry manure in equal proportion to the waste accelerates the temperature increase during composting and shortens the processing time.

Material characterization

The initial properties of the banana *pseudostem* and cocoa shell waste were determined through a literature review (Hidalgo, 2019). Following the guidelines established by Ramos (2021), the material was collected in the morning (between 9:00 AM and 10:00 AM) to avoid extreme heat exposure. Sealed, sturdy containers were used for transport to ensure material integrity.

The key physicochemical properties analyzed included moisture content, pH, and the levels of nitrogen, phosphorus, potassium, calcium, and magnesium. These parameters, as highlighted by Hidalgo (2019), provide valuable insights into the nutrient availability of the composted residues. The chemical analysis was conducted at the National Autonomous Institute of Agricultural Research (INIAP) - Pichilingue laboratory located in Quevedo canton, Los Ríos province.

Bacterial incorporation and composting process

Banana *pseudostem* and cocoa shell waste were obtained from the agricultural production areas of ESPAM MFL and transported to the Orchidarium unit. To

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expedite degradation, the waste was shredded using an electric forage chopper to achieve a particle size of 1-10 cm (Ramos, 2021).

To introduce *B. albus* and *B. wiedmannii* bacteria, solids from recycled cattle manure (SER) were used. These SER materials, as noted by Diaz and Garcia (2017), harbor abundant bacterial populations. Following the guidelines established by Herrera (2022), the manure was combined with the ground waste in a 50:50 ratio (cocoa shell:banana *pseudostem*). During the mesophilic phase, each experimental unit received 2 liters of bacterial inoculant solution for seven consecutive days, constituting 5% of the total degrading material.

After bacterial incorporation, the compost was manually moistened every two weeks. Digital Soil Tester equipment was used to monitor and control humidity, temperature, and pH. Measurements were taken three times a week, both in the morning (8:30 AM) and afternoon (5:00 PM), to minimize temperature-induced variations (Hidalgo, 2019). To promote optimal temperature increase and expedite organic matter degradation, each EU was covered with black plastic (Delgado & García, 2023). Table 2 details the specific parameters tracked throughout the composting process. This data was crucial for monitoring progress and evaluating the final compost quality in each treatment.

Table 2. Compost parameters during its degradation. Source: García & Delgado (2023)

Parameters	Ideal range that compost should have during its degradation
рН	4.5 – 8.5 Ideal range
Humidity	45%- 60% Ideal range
Temperature	ideal between 50 and 60 °C or up to 65 °C

Composting duration and analysis

The composting process lasted for 20 weeks. During the initial month, the mixture was turned every three days to manage temperature and maintain optimal humidity levels (between 45% and 60%) for efficient nutrient transport (Acosta & Peralta, 2015). Following the degradation period, the compost's physicochemical characteristics were analyzed. These included temperature, pH, electrical conductivity (EC), organic matter (OM), and macroelements (nitrogen, phosphorus, potassium). Table 3 details the specific methods used and the ideal ranges associated with high-quality compost. Physical parameter analyses were conducted at the Bromatology Laboratory within the agroindustrial area of ESPAM MFL. Chemical analyses, consistent with the previous phase, were performed at the INIAP laboratory.

Table 3. Methods for evaluating compost quality indicators. Source: Delgado & García (2023); Hidalgo (2019); Mero & Barreiro (2021).

D .		Limits		
Parameters	Methods	Class A	Class B	
Temperature	Thermometer (electrode)	5.00	5.00	
рН	Thermometer (electrode)	7.5	8.5	
Electrical Conductivity (EC)	Conductimeter	<3	<8	
Organic Matter (OM)	US EPA SW 846 Method 6010D	≥45	≥25	
C/N Ratio	Organic Matter and Nitrogen	10 - 45	45.1 - 70	
Macroelements (N, P, K)	US EPA SW 846 Method 6010D	≥0,1	≥0,6	

Carbon-Nitrogen ratio (C/N) determination

The carbon-nitrogen ratio (C/N) was evaluated to assess compost maturity. This ratio was calculated based on the percentage of organic matter (%OM) and the percentage of nitrogen (%N). Jackson's constant was employed to estimate the carbon content from the organic matter percentage. The following equation by Mero and Barreiro (2021) was used to calculate the C/N ratio:

$$\left(\frac{C}{N}\right) = \frac{(\% OM) \times 0.58}{\% N} [100]$$

Phytotoxicity test for compost maturity

The maturity of the compost was evaluated using a phytotoxicity test on cucumber seeds (Cucumis sativus) following the methodology proposed by Urriola et al. (2021). This test assessed seed germination and root elongation over three days.

The compost from the two most promising treatments was selected for this evaluation. Ten grams of each sample were weighed and directly applied to the seeds. Petri dishes lined with three layers of filter paper served as the test containers. Ten cucumber seeds were placed individually in each petri dish, and the date and time of seed contact with the substrate were documented (Urriola et al., 2021).

The plates were maintained at room temperature. Germinated seeds were counted daily at a consistent time for both the compost extract and the control group. After three days, the relative germination percentage (RGP), relative root growth (RRG), and germination index (GI) were calculated using the equations provided by Camacho et al. (2019). Table 4 summarizes the PGR and GI indicators as described by Urriola et al. (2021).

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$$RRG = \frac{Average \ root \ length \ in \ the \ extract}{Lenght \ average} x100 \ [2]$$

$$RGP = \frac{Number of germinated seeds in the extract}{Number of germinated seeds in the control} x 100[3]$$

$$GI = \frac{RGP X RRG}{100} [4]$$

Table 4. RGP and IG indicators. Source: Urriola et al. (2021).

RGP		GI	
Values less than 80%	They are considered organic waste immature	≥ 80%	Indicates that there are no phytotoxic substances, or they are in very low concentration
		$\leq 50\%$	Indicate that there is a strong presence of phytotoxic substances
		Value between 50% and 80%	It will be interpreted as the moderate presence of these substances

3. Results and discussion

Physical and chemical characteristics of banana pseudostem and cocoa shell residues

Below (Table 5) are the data for humidity, pH, nitrogen, phosphorus, potassium, calcium and magnesium of the banana *pseudostem* and cocoa shell residues.

Table 5. Physical and chemical parameters of the experimental material.

Parameters	Banana pseudostem	Cocoa shell
Humidity (%)	30.5	12.3
Ph	5.8	5.4
Nitrogen (%)	1	1.1
Match (%)	0.61	0.24
Potassium (%)	4.08	3.38
Calcium (%)	1.02	1.13
Magnesium (%)	0.24	0.28

Banana pseudostem

One of the experimental materials studied was the banana *pseudostem*, which had a humidity of 30.5% and a slightly acidic pH of 5.8. It contained 1% nitrogen (N), 0.61% phosphorus (P), 4.08% potassium (K), 1.02% calcium (Ca), and

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0.24% magnesium (Mg). These values align with the findings of Quiceno et al. (2014), who reported pH values between 4.5 and 6.5, and Murguetio et al. (2019), who found N=0.850\%, P=0.600\%, K=5.810\%, Ca=2.950\%, and Mg=0.480\%. However, the humidity value differed from Ordoñez and Sepulveda's (2019) research, which reported a humidity of 15.86\%.

The banana *pseudostem* has various characteristics that benefit plant growth and its usage. Pedraza (2019) highlighted that the humidity in the banana *pseudostem* provides a strong base for the plant to support up to 50 kg. Similarly, Hidalgo (2019) emphasized that the banana *pseudostem* contains adequate nutrients for use as a quality compost raw material.

Cocoa shell

The second experimental material used was the cocoa shell, which had a humidity of 12.3% and a pH of 5.4. It contained 1.1% nitrogen (N), 0.24% phosphorus (P), 3.38% potassium (K), 1.13% calcium (Ca), and 0.28% magnesium (Mg). The humidity values differed from those in the research by Vivanco, Matute, and Campo (2017), which reported a humidity of 8.74%. The pH values were similar to those obtained by Castillo et al. (2018), who reported a pH of 6.25. The NPK content was consistent with Puentes et al. (2015), who found N=2.07%, P=0.23%, and K=2.42%.

The cocoa shell provides proteins, carbohydrates, lipids, and minimal quantities of vitamin C (around 0.5 to 2 mg per 100 g of shell). These values can vary slightly depending on the variety of cocoa and growing conditions. Additionally, the cocoa shell contains phenolic compounds, which benefit compost production (Vivanco et al., 2017).

Influence of bacteria of the genus bacillus on the quality of compost

Temperature

The composting piles began with an ambient temperature that fluctuated between 28.3°C and 29.9°C, then varied during the four months of monitoring. T1 (Banana / *B. wiedmannii*) presented the lowest temperature at 26.4°C in week 8, while in week 14 it reached a maximum temperature of 33.5°C. T2 (Banana / *B. albus*) had its lowest temperature value in the last two weeks of monitoring, while in week 14 it obtained its maximum temperature of 33.5°C. T3 (Cocoa/ *B. wiedmannii*) maintained constant temperatures during the four months of monitoring; however, in week 8 it showed a temperature of 27.5°C, this being the lowest, and reached a maximum temperature of 33.7°C. In T4 (Cocoa / *B. albus*), in week 3 it reached a temperature of 34.1°C, the remaining weeks were

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maintained between 30°C and 32°C, ending with a temperature of 25.5°C (Figure 2).

These values agree with what was indicated by Villarreal et al. (2018) that the temperature is between the ranges of 20°C to 45°C, as it is optimal for the growth of the bacteria used, and thus, when turning, the reduction of pathogens and bad odors is achieved. Therefore, Bohórquez (2021) indicates that microbial activity increases the temperature of the composting process. In this way, it is possible to see the evolution in efficiency and the degree of stabilization that the process has reached since there is a direct relationship between temperature and the degradation of organic matter.



Figure 2. Compost temperature during degradation.

Humidity

At the beginning of the monitoring period, the humidity levels were recorded at 63.0% for T1, 63.4% for T2, 62.9% for T3, and 62.8% for T4 (Figure 3). Over the four months of monitoring, the humidity gradually decreased. Between weeks 5 and 8, the humidity levels were consistently around 55.1% for T1, 55% for T2, 55% for T3, and 55.1% for T4. By weeks 13 and 14, the values had further decreased, reaching 43% for T1, 42% for T2, 43% for T3, and 41% for T4. These findings align with the research by Cajusol and Moisupe (2019), who reported humidity values between 42% and 31% after 3 months and 2 weeks.

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Figure 3. Compost moisture during degradation.

Optimal humidity values for the growth of microorganisms range between 40% and 60%; values lower than this range can decrease microbial activity and delay the composting process (García, 2022). The compost's humidity must be such that water does not completely fill the pores, allowing for the circulation of oxygen and the reaction of other produced gases.

In the final phase of composting, the temperature should be maintained between 50°C and 70°C (García, 2022). Excess humidity can be mitigated with better aeration, which also helps in temperature control. The optimal humidity varies depending on the type of waste, as it is crucial for nourishing microorganisms and transporting nutrients during organic decomposition (Bohórquez, 2021).

pH (Hydrogen Potential)

At the beginning of the composting process, the pH value ranged between 6 and 6.5. In week 2, T2 recorded a pH of 5.8. Between weeks 9 and 12, the pH levels stabilized within a neutral range: T1 ranged from 6.7 to 7.2, T2 maintained a pH of 7, T3 ranged from 6.7 to 7, and T4 ranged from 6.6 to 7. In weeks 13 and 14, T1 showed a slightly alkaline pH of 7.9, and T2 had a pH of 8.2, while T3 presented pH values ranging from 6.3 to 7.4, and T4 from 6.3 to 7.5 (Figure 4).

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Figure 4. pH of the compost during degradation.

These findings align with Cajusol and Moisupe (2019), who reported pH values between 6.9 and 7.3, emphasizing that increased temperature indicates thermophilic microbial activity. Chávez and Tréboles (2023) state that pH significantly influences the composting process by affecting microbial activity and serving as an indirect indicator of aeration levels. Under anaerobic conditions, organic acids are generated, lowering the pH and inhibiting organic degradation. Therefore, maintaining a pH above 7.5 during the composting process is an indicator of effective decomposition (Bohórquez, 2019).

Likewise, the data from the measurement of humidity, temperature, electrical conductivity (EC), organic matter (OM), macroelements and microelements of the compost as a final product are presented (Table 6).

pН

The pH values of the different compost treatments were alkaline, with the highest value being T1 at an average of 9.55 and the lowest being T2 at 9.39. These results were higher than those reported by Rivero (2015), where the pH ranged between 7.03 and 7.43. However, they were comparable to the findings of Monges et al. (2020), who reported values between 8.27 and 9.6.

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Parameters	T $_1$	T $_2$	Τ ₃	T $_4$
pН	9.55	9.39	9.53	9.39
Temperature	26.1	26.5	26.85	27.0
Electrical conductivity (EC)	5.53	5.56	3.68	3.38
Organic matter (OM)	50.33	54.88	55.33	59.4
C/N Ratio	14.24	14.47	14.93	17.8
Nitrogen (N)	2.05	2.2	2.15	1.93
Phosphorus (P)	0.61	0.61	0.63	0.63
Potassium (K)	2.76	2.61	2.62	2.52

Table 6. Physicochemical characteristics of compost.

As shown in Table 7, the ANOVA analysis evaluated the influence of each treatment and the interaction between the bacteria and residue factors on the pH variable. It was determined that the interaction between the two factors is not significant, as the P value was 0.949. Therefore, there is not enough evidence to reject the null hypothesis of equality.

Table 7. Analysis of Variance (SC type III).

	CS	FD	MC	F	Q
Bacteria	0.090	1	0.0900	0.96	0.34
Waste	2.25e-4	1	2.25e-4	0.002	0.96
Bacteria* waste	4.00e-4	1	4.00e-4	0.004	0.94
Mistake	11.37	12	0.093		
Total	1.21	15			

The following research provides varied statistical perspectives on the influence of each treatment on pH. Noboa (2021) and Condory and Bravo (2023) found significant statistical differences in the initial and final pH, establishing that the treatments affect the pH at different stages of the composting process. However, Moncayo (2021) did not find significant differences between the treatments, concluding that the application of microorganisms in the composting process does not influence the pH. Instead, it primarily reduces the composting time and provides nutrients to the compost. The results presented by Moncayo are similar to those obtained in the present investigation.

Temperature

The temperatures in the different treatments were as follows: T1 at 26.1°C, T2 at 26.5°C, T3 at 26.85°C, and T4 at 27.08°C. These results differ from those reported by Rivero (2015), where the temperature values of the compost ranged between 7.21 and 7.41°C.

Table 8. Analysis of Variance (SC type III).							
		CS	FD	MC			
_							

	CS	FD	MC	F	Q
Bacteria	0.390	1	0.390	2005	0.182
Waste	17.55	1	17.55	9013	0.011
Bacteria* waste	0.030	1	0.030	0.157	0.699
Mistake	23.37	12	0.1948		
Total	4.51	15			

The ANOVA analysis results presented in Table 8 indicate the influence and interaction between the variables, focusing on the factors analyzed and the temperature variable. The analysis determined that the interaction between the two factors is not significant, as indicated by the P value of 0.699. Therefore, the null hypothesis of equality is accepted. However, it is noteworthy that the waste variable individually showed a significant difference of 0.01, indicating an interaction between the waste factor and temperature in the absence of bacteria.

The Tukey test results for the residual factor and its relationship with temperature are presented in Table 9, revealing significant differences between the residual means across different temperature levels, with agricultural waste exhibiting the highest average.

Table 9. Tukey test for the residual factor, temperature. Means with a common letter are not significantly different (p > 0.05)

Waste	Socks	n	EE		
1	26.30	8	0.16	А	
2	36.96	8	0.16		В

These findings align with prior research; for instance, Moncayo (2021) reported a p-value of 0.977 in the ANOVA test, indicating no significant differences among the treatments evaluated. Similarly, Delgado and García (2023) and Gavilanes (2021) observed no statistical differences in temperature during the composting phases across various treatments. These studies collectively suggest that the treatments did not significantly affect temperature variation during composting.

Electrical Conductivity (EC)

Regarding electrical conductivity, the following results were obtained: T1 with 5.50, T2 with 5.30, T3 with 3.68, and T4 with 3.45. These values differ from those reported by Monges et al. (2020), who obtained values ranging between

1.26 and 2.2. Similarly, Rivas and Silva (2020) reported values varying between 2.8 and 11.4, noting that these values depend on the compost class (Class A and Class B).

Table 10. Analysis of Variance (SC type III).

	CS	FD	MC	F	Q
Bacteria	0.0784	1	0.0784	0.679	0.426
Waste	162.409	1	162.409	140.665	<.001
Bacteria* waste	0.1089	1	0.1089	0.943	0.351
Mistake	13.855	12	0.1155		
Total	17.81	15			

The ANOVA analysis for the electrical conductivity parameter is presented in Table 10, detailing the interactions between the factors and the evaluated parameter. It was found that the interaction between the bacteria and residue factors is not significant, with a P value of 0.351. Thus, there is insufficient evidence to reject the null hypothesis of equality.

However, it is noteworthy that while the interaction between the bacteria and residue factors did not yield significant differences, the residue factor individually influences electrical conductivity. It demonstrates statistical differences regardless of the presence or absence of bacteria.

Table 11 presents the Tukey analysis for the Residuals factor in the electrical conductivity parameter, revealing significant differences between the residual means across the two levels, with agricultural waste showing a higher average.

Table 11. Tukey test for the residual factor, electrical conductivity. Means with a common letter are not significantly different (p > 0.05)

Waste	Socks	n	EE		
1	3.53	8	0.12	А	
2	5.55	8	0.12		В

The studies referenced below provide various perspectives on the statistical influence of applied treatments on the electrical conductivity parameter. Kaqui (2023) did not find significant statistical differences in this parameter, suggesting that the treatments did not significantly affect electrical conductivity. In contrast, Condory and Bravo (2023) observed over a 30-day period that electrical

conductivity did not exhibit statistical differences. However, Delgado and García (2023) reported finding significant differences in electrical conductivity.

Organic Matter (OM)

T1 presented an organic matter (OM) value of 57.03, T2 had a value of 52.90, T3 obtained 56.71, and T4 recorded 60.76. These values are lower compared to those reported by Rivero (2015), where values ranged between 78 and 66.76. In contrast, these values align more closely with the findings of Monges et al. (2020), who reported values between 15.59 and 52.20.

Table 12 displays the results of the ANOVA analysis investigating the effects of bacteria, residues, and their interaction on the organic matter parameter, providing a statistical evaluation of their interactions. The analysis determined that the interaction between these two factors significantly affects the evaluated parameter, with a P value of 0.001. Hence, there is sufficient evidence to reject the null hypothesis of equality.

Table 12. Analysis of Variance (SC type III).

	CS	FD	MC	F	Q
Bacteria	74,563	1	74,563	183,953	< .001
Waste	0.226	1	0.226	0.557	0.470
Bacteria* waste	90,821	1	90,821	224,062	< .001
Mistake	4,864	12	0.405		
Total	170.47	15			

Additionally, individual parameter ANOVA analysis reveals that the bacteria factor independently exerts significant effects on organic matter, with a p-value of 0.01. This underscores that bacteria play a significant role in influencing this parameter.

The Tukey analysis of residuals (Table 13) revealed statistically significant differences. Notably, the *B. albus* treatment within the bacteria factor exhibited the highest mean value. These findings align with Chávez and Tréboles (2023), who reported significant statistical differences. However, Delgado et al. (2018) observed no significant differences in only one treatment, attributing this to reduced carbon levels during composting. Similarly, Muñoz et al. (2020) also found significant statistical differences in their research.

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Table 13. Tukey test for the bacteria factor, organic matter. Means with a common letter are not significantly different (p > 0.05)

Waste	Socks	n	EE		
1	52.83	8	0.93	А	
2	57.15	8	0.93		В

Tukey's test results (Table 14) reveal statistically significant differences between treatment means. Notably, treatment 4 exhibits a considerably higher mean compared to treatments 1, 2, and 3. This suggests that treatment 4 has a significantly greater effect.

Table 14. Tukey test. Means with a common letter are not significantly different (p > 0.05)

Treatments	bacteria	Waste	Socks	Ν	EE			
1	1	1	50.33	4	0.32	А		
2	2	1	50.88	4	0.32		В	
3	1	2	55.33	4	0.32		В	
4	2	2	59.41	4	0.32			С

C/N ratio

The C/N ratios of the treatments ranged from 14.24% (T1) to 17.85% (T4). These values fall within the range reported by Barreros (2017) of 14.92% to 20.48%. However, they are lower than the 20% to 30% range observed by Quituisaca (2023). Notably, Mero and Barreiro (2021) suggest an optimal C/N ratio between 10% and 45% for finished Class A compost, indicating that all treatments have the potential to become suitable compost.

Table 15. Analysis of Variance (SC type III).

	\ J 1				
	CS	FD	MC	F	Q
Bacteria	9,657	1	96,566	306	<.001
Waste	16,954	1	169,538	537	<.001
Bacteria* waste	6,983	1	69,828	221	<.001
Mistake	0.379	12	0.0315		
Total	9,657	15			

A two-way ANOVA was conducted to assess the independent and interactive effects of bacteria and residue factors on the C/N ratio. The analysis revealed a significant interaction effect (p = 0.001), indicating that the influence of one

factor (bacteria or residue) on the $\mathrm{C/N}$ ratio depends on the level of the other factor.

Tukey's multiple comparison test (Table 16) revealed no significant difference (p < 0.01) between the C/N ratios of treatments 1 and 2. However, treatments 3 and 4 formed a statistically distinct group with a higher mean C/N ratio, particularly treatment 3. This suggests treatment 3 may be favorable for achieving a higher final C/N ratio in the compost.

Table 16. Tukey test. Means with a common letter are not significantly different (p > 0.05)

Treatments	bacteria	Waste	Socks	Ν	EE			
1	1	1	14.24	4	0.09	А		
2	2	1	14.27	4	0.09	А		
3	1	2	14.97	4	0.09		В	
4	2	2	14.85	4	0.09			С

Table 17 reveals that the compost's pH falls outside the acceptable range for Class A and B composts, indicating a potential issue with high alkalinity. However, the electrical conductivity falls within the permissible limits for Class B compost. Fortunately, the organic matter content, C/N ratio, and macroelement levels (nitrogen, phosphorus, and potassium) all meet the standards for Class A compost, signifying good quality in these aspects. This suggests the compost may be suitable for some applications despite the elevated pH.

Table 17. Compost quality classification.

Parameters	Results (av	erage)
	Type	
рН	9.47	В
Electrical Conductivity (EC)	4.54	В
Organic Matter (OM)	54.99	А
C/N Ratio	15.38	А
Ν	2.08	А
Q	0.62	А
k	2.63	А

Overall, the C/N ratios of all treatments fall within the range for Class A compost (refer to Table 17 for specific values), indicating a moderate availability of nitrogen and carbon for plant uptake. Interestingly, treatment T4 exhibited a

C/N ratio closest to the ideal range for mature compost, suggesting it may be the most optimal treatment as an organic fertilizer. This aligns with the findings of Quituisaca (2023), who observed a continued release of available nitrogen during crop use as the compost degrades further.

However, it's important to consider the wider context of C/N ratios in compost maturity. Hoseini (2021) reported significant differences in C/N ratios around 30, with relationships between treatments decreasing as the compost matured (evidenced by a lower C/N ratio). In contrast, Condezo (2018) did not observe significant differences in C/N ratios between treatments. These contrasting findings highlight the potential influence of various factors beyond just C/N ratio on compost maturity and suitability for specific applications.

Macroelement content

The analysis focused on three key macroelements: nitrogen (N), phosphorus (P), and potassium (K). Treatment T4 exhibited the highest nitrogen content (2.2%), followed by T3 (2.15%), T1 (2.05%), and T2 (1.93%). Phosphorus levels were fairly consistent across treatments, with both T1 and T2 showing 0.61% and T3 and T4 showing slightly higher values at 0.63%. Potassium content followed a similar pattern to nitrogen, with T4 having the highest value (2.73%) and T2 having the lowest (2.61%).

For comparison, the study by Rivero (2015) reported a range of 1.86% to 2.11% for nitrogen and 2.35% to 3.05% for potassium. While the nitrogen content in all treatments falls within this range, the potassium levels in this study are slightly higher than the upper limit reported by Rivero (2015).

Nitrogen

The ANOVA analysis (Table 18) revealed no significant interaction effect (p = 0.337) between the bacteria and residue factors on the macroelement content. This suggests that the influence of one factor (bacteria or residue) on the macroelement levels does not depend on the level of the other factor. It's important to note that these findings differ from those reported by Chávez and Tréboles (2023), who observed a significant interaction effect with values ranging from 0.38% to 2.28%. These discrepancies may be due to differences in experimental design, materials, or specific macroelements analyzed.

The impact of treatments on nitrogen content appears to be context-dependent. Anchundia (2020) observed significant differences between treatments (p = 0.00018), suggesting certain treatments can influence nitrogen content. Conversely, Goya (2013) and Condezo (2018) found no significant differences in

nitrogen (or overall macronutrients) amongst their treatments using ANOVA analysis. These contrasting findings highlight the potential influence of various factors beyond just the treatments themselves.

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	CS	FD	MC	F	Q
Bacteria	2.50e-5	1	96.56	0.005	0.940
Waste	0.00160	1	169.53	0.379	0.549
Bacteria* waste	2.50e-5	1	69.82	0.005	0.940
Mistake	0.05055	12	0.031		
Total	0.54	15			

Table 18. Analysis of Variance (SC type III).

The impact of treatments on nitrogen content appears to be context-dependent. Anchundia (2020) observed significant differences between treatments (p = 0.00018), suggesting certain treatments can influence nitrogen content. Conversely, Goya (2013) and Condezo (2018) found no significant differences in nitrogen (or overall macronutrients) amongst their treatments using ANOVA analysis. These contrasting findings highlight the potential influence of various factors beyond just the treatments themselves.

Phosphorus

The ANOVA analysis of the phosphorus content (Table 19) revealed no significant interaction effect (p = 0.940) between the bacteria and residue factors. This indicates that the influence of one factor (bacteria or residue) on phosphorus levels is not dependent on the level of the other factor.

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	CS	FD	MC	F	Q
Bacteria	2.50e-5	1	2.50e-5	0.005	0.940
Waste	0.001	1	0.001	0.379	0.549
Bacteria* waste	2.50e-5	1	2.50e-5	0.005	0.940
Mistake	0.050	12	0.00421		
Total	0.05	15			

Table 19. Analysis of Variance (SC type III).

Similar to nitrogen content, the impact of treatments on phosphorus appears to be study dependent. Chávez and Tréboles (2023) reported statistically significant differences in phosphorus content within their compost materials, ranging from 0.07% to 0.56%. These values fall within the range considered suitable for high-quality compost by Castillo (2020), suggesting the applicability of our findings despite potential variations.

However, other studies have shown contrasting results. Condezo (2018) did not observe any significant influence of treatments on phosphorus in their research. In contrast, Condory and Bravo (2023) and Zambrano and García (2023) found significant differences in phosphorus content between treatments using variance tests. These discrepancies highlight the potential influence of various factors beyond just the treatments themselves, such as the type of feedstock materials used.

Potassium

The ANOVA analysis for potassium content (Table 20) revealed no significant interaction effect (p = 0.940) between the bacteria and residue factors. This suggests that the influence of one factor (bacteria or residue) on potassium levels does not depend on the level of the other factor.

Table 20. Analysis of Variance (SC type III).

	CS	FD	MC	F	Q
Bacteria	0.058	1	0.058	0.40	0.539
Waste	0.056	1	0.056	0.38	0.547
Bacteria* waste	0.002	1	0.002	0.01	0.893
Mistake	1,761	12	0.146		
Total	1.88	15			

The potassium content in this study did not exhibit a significant interaction effect between the bacteria and residue factors (p = 0.940, Table 20). This is unlike the findings of Chávez and Tréboles (2023) who observed significant differences in potassium content due to both material and size variations. It's important to consider the overall potassium levels in the context of compost quality. Alurralde et al. (2023) suggest a range of 0.3% to 1.0% potassium for good compost. While Condory and Bravo (2023) found statistically significant differences between treatments, they also reported greater uniformity in potassium readings, potentially indicating a material or process factor influencing overall potassium content. In contrast, Condezo (2018) observed no significant differences in potassium content between treatments. These contrasting findings highlight the potential influence of various factors beyond just the treatments themselves, and the importance of considering the overall potassium level for compost quality.

The analysis (Table 20) revealed no significant interaction effect (p > 0.05) between the bacteria and residue factors on potassium content. This suggests that the variations observed in potassium levels are not directly influenced by how these two factors interact with each other. However, it's important to note

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that statistically significant differences were found in other parameters like pH, temperature and macroelements (N, P, K) across the treatments.

Based on these findings, treatment T3 appears to be the most effective overall. Treatment T4 also exhibited significant statistical differences in macroelements, suggesting some comparability in terms of nutrient content. However, further evaluation considering all the parameters (pH, temperature, etc.) might be necessary to definitively determine the optimal treatment for specific applications.

Compost maturity assessment: phytotoxicity test with cucumber seeds

Table 21 summarizes the results of the phytotoxicity test on cucumber seeds, which was conducted to evaluate the maturity of the two most promising treatments identified based on the physicochemical properties analyzed in the previous phase. The test measured three key parameters:

Table 21. CRR, PGR and GI results of the two best treatments.

Species	Treatment	RRG	RGP	GI
	T 3 R 1	85.94	71.67	61.65
	T 3 R 2	90.28	67.22	60.85
	T 3 R 3	91.18	72.69	66.38
	T 3 R 4	93.67	80.15	74.89
Commuters	Control	80.55	68.25	60.00
Cucumber	$T_{4}R_{1}$	87.72	71.96	63.27
	T 4 R 2	89.92	69.64	62.70
	T 4 R 3	89.34	71.96	62.43
	T 4 R 4	95.04	61.27	59.58
	Control	81.33	70.55	61.00

The phytotoxicity test revealed a positive effect of treatment T4R4 on cucumber root development. This treatment exhibited the highest relative root growth (RRG) of 95.04 compared to the control and other treatments (Table 21). Conversely, treatment T3R1 displayed the lowest RRG value (85.94). These findings suggest that T4R4 may have low concentrations of phytotoxic substances or even contain compounds that stimulate root growth, leading to its superior performance in the RRG test.

The t-test analysis (Table 22) revealed no statistically significant differences (p > 0.05) between the treatments for RRG, relative germination percentage RGP, and GI. This suggests that neither treatment significantly impacted root development, germination, or disease presence in cucumber seeds. However, it's important to consider the individual treatment responses within the observed

range. While all treatments achieved an RRG above 80% (similar to Urriola et al., 2021 and Camacho et al., 2019), some variations were observed. Treatment T3R4 exhibited the highest RRG (95.04), potentially indicating minimal phytotoxicity or the presence of root-stimulating compounds.

Table 22. T-student test for the parameters RRG, RGP, GI.

Classification	Variable	n	Half	p-value
Treatments	RRG	4	72.93	0.296
Treatments	RGP	4	65.94	0.194
Treatments	GI	4	92.54	0.330

The RGP data revealed complete seed germination across treatments, with some variation in percentage. Treatments T3R2 and T4R4 showed the lowest germination percentages (67.22% and 61.27%, respectively), while T3R4 had the highest (80.15%). The control group achieved a germination rate of 68.25%. These findings suggest that some level of phytotoxic agents might still be present in the compost, potentially affecting germination in some treatments.

The GI values also suggest potential variations in compost maturity. T3R4 displayed the highest GI (74.89), followed by the control (60.00) and T4R4 (59.58). While these values fall below those reported by Huerta et al. (2015) who suggested a minimum of 100% for mature compost, they are still above the threshold for immature compost proposed by Urriola et al. (2021) (below 80% GI).

Conclusions

The initial characterization of the banana *pseudostem* (30.5% humidity, pH 5.8) and cocoa shell (12.3% humidity, pH 5.4) revealed key differences. The *pseudostem* had higher moisture content and slightly lower acidity compared to the cocoa shell. The cocoa shell, however, stood out for its content of calcium, magnesium, vitamins, and proteins, while the *pseudostem* offered a higher concentration of macronutrients. During the composting process, the temperature peaked at 33.7°C before stabilizing at 25.5°C. The initial pH (6.0-6.5) increased to a range of 7.4-7.5 within four months, indicating a shift towards a more neutral environment.

The presence of Bacillus bacteria and its potential impact on compost quality were also investigated. A decrease in overall humidity was observed, dropping from an initial range of 62.9%-63% to around 42% by the end of the process.

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This decrease can be attributed to both the decomposition activity of the bacteria and the initial moisture content of the agricultural waste. Interestingly, treatments T3 and T4 (including cocoa shell) showed a greater decrease in humidity, suggesting a potential influence of the feedstock on moisture dynamics. On the other hand, treatments containing *Bacillus albus* (T2 and T4) appeared to be more efficient in overall decomposition. Statistical analysis using ANOVA and Tukey's Test revealed significant differences between treatments. Treatment T3 (cocoa shell with *B. wiedmannii*) stood out in terms of pH, temperature, electrical conductivity, and organic matter content. Treatment T4 excelled in terms of macroelement content (N, P, and K).

The phytotoxicity test with cucumber seeds was used to evaluate compost maturity. Treatment T4R4 exhibited the highest RRG at 95.04, suggesting the presence of beneficial compounds and minimal phytotoxic substances. Conversely, treatment T3R1 displayed a lower RRG (85.94), potentially indicating higher concentrations of unmetabolized phytotoxic agents. However, it is important to note that the t-student test did not detect statistically significant differences between treatments for RRG, RGP or GI.

We believe that our research demonstrates the effectiveness of the procedures tested for enhancing the quality of compost through bacillus bacteria, with significant potential for contributing to waste management and its potential use in agriculture.

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Assessing campus sustainability practices. A systematic literature review

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- 1. Introduction
- 2. Methodology
- 3. Results and Discussion
 - 3.1. Descriptive statistics
 - 3.2. Keywords co-occurrence analysis
 - 3.3. Article classification
 - 3.4. Discussion
 - 3.5. Assessing campus sustainability through key variables
- 4. Conclusions

Keywords: campus sustainability; higher education institutions; sustainability assessment; sustainability framework; systematic literature review.

Abstract. Higher education institutions (HEIs) play a critical role in advancing global sustainability goals through their operations, academic programs, and community engagement. This systematic literature review evaluates sustainability practices in HEIs, focusing on assessment frameworks and methodologies. Using a PRISMA-based process and Scopus as the primary database, 39 relevant articles were analyzed. The findings



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reveal the adoption of diverse frameworks, including the STARS system and UI GreenMetric, as well as the integration of sustainability principles into curricula, campus operations, and research. However, challenges such as resource constraints, limited stakeholder awareness, and infrastructural barriers hinder effective implementation. The study highlights the need for comprehensive, localized assessment tools to enhance HEIs' contributions to promoting sustainability. Future research should develop innovative frameworks and strategies to foster sustainability literacy and practices within academic communities. By addressing current trends, challenges, and opportunities, this review advances the discourse on sustainability in HEIs and offers actionable insights for enhancing institutional practices.

1. Introduction

Higher Education Institutions (HEIs) play a pivotal role in shaping future generations and addressing global sustainability challenges. As centres of knowledge creation and innovation, HEIs are uniquely positioned to influence sustainable development practices both locally and globally. Recent years have seen a growing focus on sustainability in higher education, driven by the need to address pressing environmental, social, and economic concerns (Henderson et al., 2022). Incorporating sustainability into HEIs can profoundly impact campus operations, academic outcomes, and community engagement.

Sustainability initiatives within HEIs typically aim to reduce carbon emissions, enhance resource efficiency, and promote social responsibility through equitable policies and community programs. By integrating sustainability into their operations and curricula, HEIs can act as exemplars and drivers of sustainable change.

HEIs function as "small cities," managing significant resources and generating waste. Without sustainable practices, these activities can lead to considerable environmental degradation. Establishing environmental management systems allows universities to not only comply with environmental standards but also integrate sustainability principles into teaching, research, and outreach. Such

systems can enhance operational efficiency while mitigating environmental impacts (Alshuwaikhat and Abubakar, 2008).

A holistic approach to sustainability also emphasizes public engagement and social accountability. Engaging students, faculty, and the broader community fosters inclusivity and encourages collaborative efforts to address sustainability challenges. Initiatives like green buildings, sustainable transportation, and energy efficiency programs highlight the potential for campuses to lead by example. Beyond reducing negative environmental impacts, sustainability strategies contribute to broader economic, social, and environmental well-being.

Despite their potential, HEIs face significant barriers to implementing sustainability programs. Challenges include competing institutional priorities, limited resources, and organizational complexity. Effective sustainability efforts require embedding sustainability principles within institutional culture, governance, and policies, rather than treating them as isolated initiatives. Evaluating the effectiveness of sustainability programs is crucial for identifying gaps, ensuring accountability, and fostering continuous improvement (Basheer et al., 2023).

Systematic assessment tools enable HEIs to measure progress, highlight areas for enhancement, and demonstrate accountability. Without a structured evaluation framework, institutions risk losing focus and failing to meet sustainability goals. Assessments provide critical insights for stakeholders, administrators, and policymakers, facilitating data-driven decision-making and strategic planning (Ma et al., 2022). By examining global frameworks and methodologies, HEIs can refine their approaches to achieving sustainability.

This study aims to address the following research questions:

- 1. To what extent has research on sustainability assessment in higher education institutions been undertaken?
- 2. What frameworks and methodologies are used to evaluate sustainability initiatives?
- 3. What areas require further investigation to improve sustainability practices in HEIs?

Understanding sustainability assessment processes enables HEIs to adapt frameworks to their specific needs, addressing gaps and leveraging opportunities. The findings of this study contribute to academic literature and support global efforts to achieve sustainable development goals.

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The structure of this paper is organized as follows. Section 2 outlines the methodology, employing the PRISMA framework for systematic reviews. Section 3 presents the results and discussion, highlighting key findings and implications. Section 4 concludes the paper with recommendations and suggestions for future research.

2. Methodology

This study employs the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure a transparent and replicable selection process. PRISMA is widely utilized in systematic literature reviews to filter and refine relevant studies from large databases (Page et al., 2021). While traditionally used in health sciences, PRISMA has increasingly been applied in sustainability research, particularly in evaluating environmental and higher education sustainability studies (Zhu et al., 2022; Alghamdi et al., 2023). By adopting PRISMA, this study ensures a structured approach to identifying and selecting relevant literature on campus sustainability assessment.

This study uses Scopus as the principal source for gathering articles pertinent to the research issue. Scopus was selected because of its status as one of the largest and most reputable academic databases, encompassing a diverse array of fields. While Scopus provides extensive coverage, potential limitations include the exclusion of non-English sources and articles outside indexed journals, which could marginalize relevant findings.

A search was performed utilizing the following query: TITLE-ABS-KEY ("campus sustainability") AND TITLE-ABS-KEY ("Assess"). This combination was crafted to ensure that the selected articles concentrate on campus sustainability and related evaluative techniques. The keywords were chosen based on their relevance to the research topic and their capacity to encompass a broad range of sustainability assessments.

To assess the effectiveness of the chosen search query, we conducted preliminary tests with alternative keyword combinations, including:

- TITLE-ABS-KEY ("higher education sustainability") AND TITLE-ABS-KEY ("assessment frameworks")
- TITLE-ABS-KEY ("university sustainability") AND TITLE-ABS-KEY ("evaluation methods")

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• TITLE-ABS-KEY ("green campus initiatives") AND TITLE-ABS-KEY ("performance measurement")

The preliminary tests indicated that while alternative queries retrieved additional studies, they also increased the inclusion of articles that were tangentially related to campus sustainability assessments, reducing specificity. The final keyword selection was determined based on a balance between precision and recall, ensuring the focus remained on relevant academic contributions to sustainability assessment within HEIs. A total of 116 articles that met the criteria were successfully identified at completion of the search process.

Subsequently, the study implemented a series of filtering procedures to guarantee that the examined papers correspond with the research issue, namely campus sustainability and its evaluation methodologies. Figure 1 illustrates the article filtration procedure employed in this study utilizing the PRISMA framework.

The initial filtering phase involved the titles, during which the study excluded publications with titles irrelevant to the research subject. Criteria for exclusion included terms unrelated to sustainability, such as financial audits or unrelated assessments. This method led to the removal of 41 articles, resulting in 75 articles considered pertinent.

The second filtering phase concentrated on the abstracts. At this point, the abstracts of each publication were assessed to confirm their relevance to the research topic. 17 papers were removed from this evaluation due to their abstracts not corresponding with the research topic. Subsequent to this phase, 58 articles fulfilled the criteria. A comprehensive full-text search was performed to verify the complete accessibility of the pertinent articles. Three papers were inaccessible and were therefore excluded, resulting in 55 articles for subsequent analysis.

The final filtering stage entailed a comprehensive examination of the complete content of the surviving articles. At this juncture, the study scrutinized each article meticulously to verify its pertinence to the subject of campus sustainability. Consequently, 16 articles were removed for lacking relevance to the subject matter. The filtering technique resulted in the selection of 39 articles for subsequent study. Figure 1 depicts the PRISMA procedure.

To determine whether the selected 39 papers comprehensively represent the field, we performed additional validation steps. First, we examined whether the selected studies frequently cited each other. The analysis showed that a majority of the selected papers referenced key sustainability assessment frameworks and

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prior research in HEIs, reinforcing their relevance. Additionally, a manual review of references in the 39 selected studies identified a few frequently cited works that were not included in our dataset. While this suggests that some critical studies may have been overlooked, the overall representation of the key literature was deemed sufficient. Lastly, thematic mapping of the selected studies aligned with major sustainability trends in HEIs, confirming that the dataset's composition accurately reflected the broader discourse on campus sustainability assessment.





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3. Results and Discussion

3.1 Descriptive statistics

A vital aspect of systematic analysis is comprehending the temporal distribution of publications. Figure 2 depicts the quantity of articles concerning campus sustainability categorized by their year of publication. This analysis seeks to discern temporal trends in research and examine the evolution of attention to this topic across time. The apex of publications transpired in 2020, denoting the year with the greatest number of articles in this dataset. This increase likely reflects growing global awareness following the adoption of the Sustainable Development Goals (SDGs) in 2015 and their progressive integration into institutional frameworks.

In contrast, the fewest publications were noted during the initial years of the analysis period, specifically from 2003 to 2011, when publications were scarce, with certain years reporting no papers whatsoever. This highlights the relatively recent emergence of campus sustainability as a research priority.



Figure 2. Number of publications by year

The examination of publication counts by journal seeks to pinpoint the principal sources for research pertaining to campus sustainability. This is crucial for identifying key outlets and supporting researchers in locating credible reference sources. Figure 3 illustrates the quantity of publications by journal pertaining to this subject. The International Journal of Sustainability in Higher Education

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stands out with 12 articles, likely due to its specialized focus on sustainability and higher education. Sustainability (Switzerland) follows closely with 11 pieces, reflecting its broad scope and commitment to sustainability topics.



Figure 3. Number of publications by journal

The examination of the most prolific authors in campus sustainability research identifies key contributors to the field. Figure 4 highlights Adenle, Alshuwaikhat, and Abubakar, each with three publications, as the most active authors. Their research primarily focuses on sustainability frameworks, environmental management systems, and policy integration in higher education institutions. Additionally, Aina and Chan with two publications each, complement the dataset by contributing relevant insights, including case studies and practical applications, as the most active authors. Their work emphasizes sustainability frameworks and environmental management systems in higher education.

An analysis of citation counts reveals influential publications in campus sustainability. Figure 5 identifies Alshuwaikhat and Abubakar's (2008) paper with 653 citations as the most referenced work. Subsequent studies have built upon their findings by adapting and expanding the University Environmental Management System (UEMS) model to suit diverse institutional and regional contexts, further validating its impact. Its high citation count highlights its impact in shaping sustainability discussions and guiding institutional practices.

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Figure 4. Top 5 most active author.



Figure 5. Top 10 most cited article

3.2 Keywords co-occurrence analysis

To analyze the thematic structure of campus sustainability research, we employed VOSviewer for keyword co-occurrence analysis. VOSviewer groups keywords into clusters based on their co-occurrence patterns in the selected studies, forming visualized networks where closely related terms appear together (van Eck & Waltman, 2010). This clustering method helps reveal underlying themes in the literature by identifying frequently associated terms and grouping them into meaningful categories. The keyword co-occurrence method provided valuable insights by highlighting dominant themes and confirming expected

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research trends. It reinforced findings from our literature review by emphasizing well-established areas such as environmental policies and energy efficiency in HEIs.

In the visualized network, a network map is formed by applying nodes and lines connecting the nodes. A node symbolizes a particular bibliographic item, such as keywords, article, journal, institution, or country. The node size denotes the counting of the evaluated item, i.e., citation or occurrence. The link denotes the co-citation, co-occurrence, or collaboration relationship. There are three steps to construct the map. In the first step, a similarity matrix is calculated. VOSviewer uses a similarity measure known as the association strength (van Eck & Waltman, 2010; van Eck et al., 2006). Using this association strength, the similarity s_{ij} between two items *i* and *j* is calculated as

$$s_{ij} = c_{ij} / (w_i \cdot w_j) \tag{1}$$

where *c_{ij}* denotes the number of co-occurrences of co-cited of items *i* and *j*, and w_i and w_j denote either the total number of occurrences (or co-cited) of items i and j or the total number of co-occurrences (or co-cited) of these items. The second step is constructing the map based on the similarity matrix obtained in the previous step. Let n denote the number of items to be mapped. The mapping technique constructs a two-dimensional map in which the items 1, 2, ..., n are located in such a way that the distance between any pair of items *i* and *j* reflects their similarity *s_{ii}* as accurately as possible. Items that have a high similarity should be located close to each other, while items that have a low similarity should be located far from each other. The idea of the mapping technique is to minimize a weighted sum of the squared Euclidean distances between all pairs of items. The higher the similarity between two items, the higher the weight of their squared distance in the summation. To avoid trivial maps in which all items have the same location, the constraint is imposed that the average distance between two items must be equal to 1. In a mathematical notation, the objective function to be minimized is given by

$$V(\mathbf{k}_{1}, \mathbf{k}_{2}, ..., \mathbf{k}_{n}) = \sum_{i < j} s_{ij} \left\| k_{i} - k_{j} \right\|^{2}$$
(2)

where the vector $k_i = (k_{i1}, k_{i2})$ denotes the location of item *i* in a two-dimensional map; and $||\cdot||$ denotes the Euclidean norm. Minimization of the objective function is performed subject to the constraint

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$$\frac{2}{n(n-1)} \sum_{i < j} \left\| k_i - k_j \right\| = 1$$
(3)

The optimization problem discussed in the second step does not have a unique globally optimal solution. It is of course important to produce a consistent result, i.e., the same co-occurrence matrix should therefore always yield the same map (ignoring differences caused by local optima). To accomplish this, in the third step, it is necessary to transform the solution obtained for the optimization problem discussed in the second step. There are three transformations applied, namely, translation (the solution is translated in such a way that it becomes centered at the origin), rotation (the solution is rotated in such a way that the variance on the horizontal dimension is maximized), and reflection (if the median of k_{11}, \ldots, k_{n1} is larger than 0, the solution is reflected in the vertical axis; on the other hand, if the median of k_{12}, \ldots, k_{n2} is larger than 0, the solution is reflected in the origin to ensure consistent results.

Figure 6 illustrates the outcomes of the network visualization, emphasizing the relationships among keywords derived from the examined literature. The identified clusters were compared against the full-text analysis of the 39 selected studies to assess their alignment with key research themes. The clusters largely reflected major topics in sustainability assessment, including environmental impact, institutional sustainability policies, and student engagement. This assessment confirms that the clusters largely align with major research themes such as environmental impact, sustainability policies, and student engagement, but also reveals some unexpected patterns, such as the lower frequency of terms related to climate adaptation. Prior research has similarly assessed campus sustainability using different evaluation methods (Ulkhaq et al., 2016, 2019a; Pramono et al., 2017; Setyorini et al., 2016). However, some clusters contained broad or overlapping terms that required further contextual interpretation. For example, the cluster around "sustainability curriculum" included terms related to both policy implementation and pedagogical strategies, highlighting the multidimensional nature of sustainability education.

The results categorized the terms into six groups based on proximity and connection, illustrating the primary themes of this research. Table 1 presents a comprehensive analysis of the keywords in each cluster. These clusters highlight key themes, including 'environmental management,' 'policy frameworks,' 'assessment methods,' 'institutional governance,' 'community engagement,' and 'education for sustainability.' These themes reflect distinct yet interconnected

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focal points in campus sustainability research. The analysis of term clustering enables researchers to discern principal subject areas and their interconnections, offering a systematic view of academic discourse around sustainability in higher education. Table 1 presents a comprehensive analysis of the keywords in each cluster. These clusters represent separate yet interrelated research domains, reflecting diverse focal points in campus sustainability research.



Figure 6. Keywords co-occurrence network

The findings of the network visualization highlight multiple facets, such as education, environmental management, performance assessment, and institutional governance. Each cluster represents a distinct perspective, providing valuable insights for further research. This thematic diversity underscores the multifaceted nature of sustainability in HEIs, emphasizing the need for a comprehensive approach to studying and promoting this domain.

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Table 1.Cluster analysis

Cluster	Keywords
cluster 1 (Education and Environmental Management)	education, environment, environmental management, green campus, integrated approach, stakeholder, student, universities
cluster 2 (Institutional Frameworks and Sustainability Assessment)	academic research, assessment method, decision making, environmental indicator, higher education institution, institutional framework, ranking, sustainability
cluster 3 (Sustainability Performance and Regional Development)	benchmarking, China, energy efficiency, Japan, sustainability performance, sustainable development, university campus, university sector
cluster 4 (Governance and Management Practices)	Canada, governance approach, higher education institutions, management practice, questionnaire survey, Saudi Arabia, teaching
cluster 5 (Campus Sustainability Reporting and Learning)	AASHE, campus sustainability, climate change, organizational learning, stars, sustainability reporting
cluster 6 (Developing World and Sustainability Assessment)	developing world, environmental education, GIS, greenhouse gas, sustainability assessment

An overlay visualization was also generated to illustrate the temporal dynamics of term occurrences. Figure 7 presents this visualization, depicting the average year of keyword occurrences with a color gradient ranging from blue for earlier terms to yellow for more recent terms. This analysis reveals emerging research topics, such as ranking, benchmarking, and assessment methods, indicating growing interest in measuring and quantifying sustainability performance. These findings align with recent global sustainability trends and efforts to integrate sustainability indicators into institutional practices. The results emphasize the importance of establishing standardized frameworks to ensure accountability and enhance the effectiveness of sustainability initiatives in HEIs., depicting the average year of keyword occurrences with a color gradient ranging from blue for earlier terms to yellow for more recent terms. This analysis reveals emerging research topics, such as ranking, benchmarking, and assessment methods, indicating growing interest in measuring and quantifying sustainability performance. These findings highlight the importance of establishing standardized frameworks to ensure accountability and enhance the effectiveness of sustainability initiatives in HEIs.

While the keyword groupings mostly aligned with our thematic analysis, some unexpected patterns emerged. Certain terms, such as "climate adaptation," appeared less frequently than anticipated despite its relevance in sustainability discourse. This may suggest either a gap in the selected literature or the underrepresentation of specific sustainability subtopics in our dataset.

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Additionally, terms related to social equity and governance appeared in multiple clusters rather than forming distinct groups, indicating their cross-cutting relevance across various sustainability domains.



Figure 7. Keywords co-occurrence network - Overlay visualization

3.3 Article classification

Campus sustainability research is characterized by a diverse range of methodological approaches, broadly categorized into qualitative and quantitative methods (see Table 2). Qualitative research focuses on providing detailed and contextual insights through descriptive and exploratory analyses. Within this category, descriptive methods such as case studies and literature reviews are dominant. For instance, Ikegami (2020) and Chen & Vanclay (2021) utilize case studies to examine specific institutional practices, while reviews by Urbanski & Filho (2015), Suwartha & Sari (2013), and Alshuwaikhat & Abubakar (2008) synthesize existing knowledge to offer a comprehensive understanding of the field. Exploratory analyses, often employing GIS tools as demonstrated by Adenle et al. (2020), allow researchers to analyse spatial patterns and sustainability

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practices across institutions. These approaches provide nuanced insights into the complexities of campus sustainability, highlighting unique challenges and innovative practices.

Type of Research	Methods	Article	
Qualitative	Case study	Ikegami (2020), Chen & Vanclay (2021)	
	Review	Urbanski & Filho (2015), Suwartha & Sari (2013), James & Card (2012), Levy & Marans (2012), Alshuwaikhat & Abubakar (2008), Fisher (2003), Ghaus et al. (2017)	
	GIS	Adenle et al. (2020)	
	Case study	Alsharif et al. (2020)	
	Review	Hoque et al. (2017)	
	AHP	Adenle et al. (2021)	
	Case Study	Almashhour & Samara (2022), Chen & Vanclay (2022)	
	Fuzzy Inference Systems	Karasan et al. (2023)	
	GIS	Alshuwaikhat et al. (2017)	
	QAT	Du et al. (2023)	
	USFQ	Velasco et al. (2018)	
Quantitative	Regression	Washington-Ottombre (2024), Dawodu et al. (2024), Ulkhaq & George Joseph (2024), Lad & Akerlof (2022), Horan & O'regan (2021), Abubakar et al. (2020), Ali & Anufriev (2020), Washington-Ottombre & Bigalke (2018), Abubakar et al. (2016), Alshuwaikhat et al. (2016), Lidstone et al. (2015), Horhota et al. (2014), Huang et al. (2014), Kamal & Asmuss (2013), Lang (2019), Shuqin et al. (2019), Speer et al. (2020), Jiang & Kurnitski (2023). Saadatian et al. (2013). Beringer (2006)	

 Table 2. Article Classification

Quantitative research, on the other hand, is the predominant approach due to its ability to produce measurable, generalizable, and comparative outcomes. This category encompasses a wide array of analytical techniques, including the Analytic Hierarchy Process (AHP), fuzzy inference systems, and regression analysis. Adenle et al. (2021) employ AHP to develop decision-making frameworks, while Karasan et al. (2023) utilize fuzzy inference systems to model complex sustainability variables. Regression analysis emerges as the most frequently used method, applied in studies such as Washington-Ottombre (2024) and Dawodu et al. (2024), highlighting its effectiveness in predicting and validating relationships among sustainability metrics. Additionally, methods like GIS, QAT (Du et al., 2023), and USFQ (Velasco et al., 2018) provide alternative approaches for evaluating institutional performance.

The integration of qualitative and quantitative methodologies offers significant potential for advancing campus sustainability research. While qualitative methods

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excel in providing detailed, context-specific insights, quantitative approaches ensure structured, comparative, and replicable findings. Emerging methods such as fuzzy inference systems and GIS demonstrate the innovative trajectory of sustainability research, bridging the gap between qualitative depth and quantitative rigor. To further enhance the field, future studies should focus on standardizing frameworks and integrating complementary methodologies, enabling a more holistic understanding of sustainability challenges and practices across higher education institutions.

3.4 Discussion

Prior research has examined multiple facets of sustainability, encompassing student evaluations of campus sustainability, institutional sustainability frameworks, sustainability metrics for smart campuses, and the influence of individual interpretations of sustainability on perceptions of sustainability culture. Certain research has concentrated on universities in Saudi Arabia, shown by the study conducted by Abubakar et al. (2016), which indicated that while students possess a significant awareness of sustainability, their participation in campus sustainability activities is very low. A study by Abubakar et al. (2020) emphasized the absence of sustainability reporting in Saudi universities, despite the presence of sustainability visions in most institutions. Research by Alsharif et al. (2020) similarly highlighted that decision-makers' understanding and awareness of sustainability are inconsistent, with cost serving as a significant impediment. These studies illuminate the problems and potential for promoting sustainability in higher education institutions.

Research in several locales, including Adenle et al. (2021), using an analytic hierarchy process (AHP) to determine essential sustainability indicators on Nigerian campuses, with transportation recognized as the paramount sustainability factor. Simultaneously, Alexander et al. (2022) illustrated how individual interpretations of sustainability can affect campus community perceptions of sustainable culture. Moreover, numerous studies have concentrated on creating instruments or frameworks to assess campus sustainability. Alshuwaikhat et al. (2017) created a GIS-based approach to evaluate the operational sustainability of campuses, emphasizing the importance of spatial factors in sustainability assessment. These contributions highlight the variety of techniques and methodologies in campus sustainability research.

Bantanur et al. (2015) emphasized the significance of evaluating sustainability strategies in higher education institutions in India. The study indicated that knowledge of sustainability is rising; nevertheless, the application of factors like

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land usage and energy differs markedly according to geographical location and climatic circumstances. Bethurem et al. (2021) investigated Allegheny College's initiatives to diminish the use of single-use plastic water bottles via refill stations, awareness campaigns, and a complimentary bottle program. Survey findings revealed a notable reduction in plastic bottle usage since 2014, although inadequate facilities in dormitories persisted as a significant obstacle.

Washington-Ottombre (2024) assessed organizational learning outcomes resulting from the use of sustainability reporting systems, including STARS, at the organizational level. The results demonstrated that although these methods effectively disseminate extensive knowledge, profound organizational learning is still constrained. A further study by Washington-Ottombre and Bigalke (2018) determined that campus sustainability innovations are affected by external factors, like climate zones, and internal factors, such as the influence of change agents. Chen & Vanclay (2023, 2021) examined the significance of "social license to operate" for international institutions, highlighting the necessity of robust community participation and benefit-sharing to improve social sustainability and institutional reputation. These studies emphasize the interaction of external influences, internal dynamics, and community interactions in promoting sustainability in higher education.

Additionally, Cho (2019) introduced a comprehensive model to elucidate student recycling behavior on campus, demonstrating that self-motivation and recycling intents substantially impact actual practice. Cohen et al. (2018) underscored the significance of interdepartmental collaboration to facilitate sustainability activities at small campuses. Dawodu et al. (2024) emphasized the necessity for more integrated participatory approaches in sustainability assessment tools for campuses, especially among Sino-foreign universities in China. This study offered a context-driven strategy incorporating many stakeholders to improve the efficacy of sustainability assessments.

The research conducted by Ali & Anufriev (2020) examined Russian institutions, emphasizing the significance of environmental management on campuses to improve sustainability; nonetheless, the results indicated a deficiency in student awareness regarding pro-environmental efforts. Hoque et al. (2017) examined sustainability practices at universities in Bangladesh, revealing that although some initiatives are present, environmental management practices on these campuses are still constrained. Horan & O'Regan (2021) established a framework of sustainability indicators applicable to higher education institutions globally, enabling the assessment and ranking of sustainability efforts. These studies highlight the disparate levels of sustainability implementation across areas and

the necessity for standardized methods to facilitate global improvement initiatives.

Additional research, like that of Horhota M. et al. (2014), uncovered behavioral impediments to campus sustainability through a multi-method approach. Their studies indicated that inadequate communication, inconvenience, budgetary limitations, and insufficient engagement were the principal barriers. Huang et al. (2014) established a quantitative decision-making framework to aid universities in strategizing and prioritizing sustainability initiatives through the STARS system. Ikegami & Neuts (2020) performed a cluster study of higher education institutions in Japan, identifying that critical elements for campus sustainability were associated with asset management and networking, which exerted a more significant impact on sustainability efforts. These studies underscore the varied problems and options in promoting sustainability within higher education institutions across multiple environments.

Jiang and Kurnitski (2023) proposed a performance-based indicator framework to assess the sustainability of university campuses moving towards carbon neutrality. This concept entails quantifying greenhouse gas emissions and evaluating social performance. Karasan A. et al. (2023) devised a fuzzy rating system to evaluate institution sustainability, integrating qualitative criteria via human assessments. Kaza et al. (2016) advocated for the advancement of sustainable leadership via professional development initiatives for professors, emphasizing curriculum modifications that tackle sustainability issues. Lad and Akerlof (2022) assessed sustainability literacy and culture inside academic institutions, underscoring the significance of data-driven evaluations and the difficulties associated with assessing and executing sustainability at the campus population level.

3.5 Assessing campus sustainability through key variables

Campus sustainability encompasses multiple dimensions that collectively determine the effectiveness of sustainability practices within higher education institutions. The key variables presented in Table 3 were identified through a systematic analysis of the 39 selected studies. These variables were extracted by conducting a thematic synthesis of recurring concepts, frameworks, and indicators employed in campus sustainability assessments. To ensure a structured extraction process, we applied a content analysis approach, categorizing sustainability-related themes based on their frequency and significance in the reviewed literature.

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A qualitative coding process was employed to identify dominant sustainability aspects discussed across multiple sources. Specifically, we analyzed articles that evaluated sustainability in HEIs using established frameworks such as the STARS system, UI GreenMetric, and other institutional sustainability models (Alshuwaikhat & Abubakar, 2008; Ma et al., 2022). The variables in Table 3 emerged as common themes in sustainability assessments, reinforcing their relevance to campus sustainability discourse.

Table 3 provides a structured overview of these key sustainability variables and their significance, substantiated by prior research from the 39 selected articles. These variables have been established as critical elements in sustainability assessments, as demonstrated by their repeated emphasis across multiple studies. Each variable is linked to one or more reviewed studies, ensuring that the findings are grounded in empirical evidence. Furthermore, these findings align with existing sustainability evaluation tools such as STARS, UI GreenMetric, and the University Environmental Management System (EMS). Integrating these variables into assessment frameworks allows HEIs to systematically measure and enhance their sustainability performance.

As shown in Table 3, these variables range from environmental management and green infrastructure to financial strategies and socio-cultural aspects, providing a comprehensive framework for assessment. Environmental management and improvement focus on minimizing negative environmental impacts through pollution prevention, energy efficiency, and resource conservation. Effective waste reduction and recycling initiatives further support sustainability efforts by reducing operational footprints and fostering resource optimization. Similarly, the concept of a green campus emphasizes eco-friendly infrastructure, such as green buildings and sustainable transportation systems, which serve as tangible demonstrations of institutional commitment to environmental responsibility.

Public participation also plays a crucial role in advancing campus sustainability. Partnerships with government agencies, private sectors, and NGOs, along with community engagement through advisory panels and group discussions, facilitate inclusivity and shared decision-making processes. Universities further extend their influence through community service initiatives that raise public awareness and empower communities to adopt sustainable practices. Social justice is another integral aspect, promoting equity, fairness, and inclusiveness through institutional policies that address human rights, gender equality, health, and safety. This emphasis on social dimensions underscores the need for universities to balance environmental goals with broader social responsibilities.

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Table 3. Key variable	s of campus	sustainability
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Variable	Definition	Supporting References
Environmental management and improvement	Minimize negative impacts of operation, pollution prevention, energy efficiency, resource conservation, environmental improvement, waste reduction, recycling.	Alshuwaikhat & Abubakar (2008), Washington-Ottombre (2024), Jiang & Kurnitski (2023), Machado & Davim (2023)
Green campus	Green buildings, green transportation, campus preservation.	Jiang & Kurnitski (2023), Machado & Davim (2023), Dawodu et al. (2024), Cho (2019)
Public participation	Partnerships between universities, government agencies, private sectors, and NGOs; community participation through group discussions, interviews, advisory panels.	Alshuwaikat & Abubakar (2008), Cho (2019), Cohen et al. (2018), Washington- Ottombre & Bigalke (2018), Alsharif et al. (2020)
Community service	University-led sustainability awareness projects and initiatives.	Washington-Ottombre & Bigalke (2018), Bethurem et al. (2021), Grosseck et al. (2019)
Social justice	Fair treatment, equitable distribution of social benefits, gender equality, and health promotion in sustainability policies.	Abubakar et al. (2016), Ali & Anufriev (2020), Hoque et al. (2017)
Conferences, seminars, and workshops	Platforms for interdisciplinary sustainability knowledge exchange and collaboration.	Alshuwaikhat & Abubakar (2008), Lad & Akerlof (2022), Kaza et al. (2016), Huang et al. (2014)
Sustainability in courses and curriculum	Integrating sustainability into university curricula.	Alshuwaikhat & Abubakar (2008), Grosseck et al. (2019), Ma et al. (2022), Cohen et al. (2018)
Research and development (R&D)	Developing innovative solutions to environmental and social issues, including climate change mitigation and renewable energy.	Chen & Vanclay (2022), Jiang & Kurnitski (2023), Velasco et al. (2018)
Financial management	Revenue diversification, cost efficiency in sustainability projects, and investment in green initiatives.	Ali & Anufriev (2020), Dawodu et al. (2024), Jiang & Kurnitski (2023)
Socio-cultural aspect	Promoting local cultural heritage through sustainability efforts.	Sonetti et al. (2015), Cho (2019), Velasco et al. (2018)

Additionally, universities function as hubs for research, learning, and collaboration. As indicated in Table 3, hosting conferences, seminars, and workshops creates platforms for interdisciplinary knowledge exchange, enabling academics, policymakers, and industries to address pressing sustainability challenges collectively. Incorporating sustainability into courses and curricula ensures that students acquire the skills and perspectives needed to tackle environmental, social, and economic issues, preparing them to become advocates for sustainable practices in their careers and communities. Research and development (R&D) further drive innovation, generating insights and technologies that address global challenges such as climate change, renewable energy, and poverty.

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Financial management is pivotal to ensuring the long-term viability of sustainability initiatives. Universities must diversify revenue streams, manage endowment funds effectively, and reduce operational costs through energy efficiency and strategic planning. In parallel, sustainable procurement policies, such as prioritizing recycled products and eco-friendly materials, reinforce institutional commitments to responsible consumption. Socio-cultural aspects also complement these efforts by preserving cultural heritage through events and programs that promote community engagement and cultural sustainability.

While these variables provide a robust framework, challenges remain in translating concepts into measurable outcomes, particularly in areas like social justice and socio-cultural preservation. Effective integration of curriculum development, research priorities, and operational strategies requires institutional alignment and interdisciplinary collaboration. Furthermore, financial sustainability poses a persistent challenge, particularly for resource-constrained institutions, necessitating innovative financing models and partnerships. Regional adaptations also play a key role, as sustainability priorities often vary based on environmental, economic, and cultural contexts. Therefore, universities must adopt flexible, context-specific approaches to implement and assess sustainability effectively.

This analysis highlights the complexity and interconnectedness of campus sustainability variables, as summarized in Table 3, and underscores the importance of adopting holistic strategies to address both environmental and social dimensions. By leveraging these frameworks, institutions can enhance their sustainability practices and contribute meaningfully to global development goals.

4. Conclusions

This study aimed to assess campus sustainability practices through a systematic literature review, guided by three key research questions:

1. To what extent has research on sustainability assessment in higher education institutions been undertaken?

Our analysis of 39 selected studies revealed a significant increase in campus sustainability research, particularly after the adoption of the SDGs in 2015. The analysis of publication trends showed a peak in research activity in 2020, highlighting an increasing academic focus on sustainability. The most frequently cited journals in this field, including *International Journal of Sustainability in Higher*

Education and *Sustainability (Switzerland)*, indicate that sustainability research is gaining prominence within academic discourse.

2. What frameworks and methodologies are used to evaluate sustainability initiatives?

The findings indicate that sustainability assessment in higher education institutions predominantly relies on established frameworks such as STARS, UI GreenMetric, and other institutional sustainability evaluation tools. Despite their widespread use, these frameworks face challenges such as resource constraints, limited stakeholder engagement, and infrastructural barriers. The descriptive statistics also revealed that regression-based methodologies and GIS mapping are frequently employed to analyse sustainability data in HEIs.

3. What areas require further investigation to improve sustainability practices in HEIs?

The study identified research gaps based on a synthesis of the reviewed literature. The descriptive statistics revealed several *gaps* from the selected studies, including the need for more research on integrating sustainability literacy into curricula, improving institutional accountability, and developing holistic assessment methodologies. These gaps were highlighted across multiple studies that noted the lack of standardized frameworks and metrics for measuring sustainability progress in HEIs (Washington-Ottombre, 2024; Jiang & Kurnitski, 2023). Additionally, our findings suggest that innovative digital tools and participatory approaches remain underutilized, an observation supported by several reviewed studies (Dawodu et al., 2024; Chen & Vanclay, 2022). Future research should focus on refining evaluation frameworks, improving stakeholder collaboration, and leveraging advanced analytical techniques to enhance sustainability practices in higher education.

While this study provides valuable insights into sustainability assessment in HEIs, it is not without limitations. The use of PRISMA, while systematic and transparent, may introduce certain biases. Prior research has noted that PRISMA's stringent inclusion criteria often exclude exploratory or conceptual studies that provide early-stage insights into emerging trends (Page et al., 2021). Moreover, reliance on Scopus as the primary database may have led to the omission of relevant studies published in non-indexed journals, potentially limiting the diversity of perspectives included in the review (Gusenbauer & Haddaway, 2020).

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Another limitation is the reliance on existing literature, which means that any biases or gaps in prior studies are inherently carried into our findings. Some aspects of sustainability in HEIs, such as the role of cultural factors or informal sustainability initiatives, may not have been adequately addressed due to the limited availability of studies in these areas (Sonetti et al., 2015). Some studies also have explored the effectiveness of university sustainability programs from students' perspectives, highlighting the gaps in university-led initiatives (Ulkhaq et al., 2017) and the variations in student attitudes toward sustainability across institutions (Ulkhaq et al., 2019b). Future research should consider incorporating mixed-method approaches, including qualitative case studies, to provide a more comprehensive understanding of sustainability practices in HEIs.

Despite these limitations, this study offers a structured and evidence-based analysis of campus sustainability assessment. By acknowledging these challenges, we aim to enhance the transparency and credibility of our findings. Future research should explore alternative methodologies and additional data sources to address these limitations and further advance the discourse on sustainability in higher education institutions.

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Leveraging selected Local Wisdom Species in developing peatland restoration in South Sumatra, Indonesia

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- 1. Introduction
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Keywords: Local Wisdom Species (LWS); peatland restoration; rural communities; learning process.

Abstract. This paper examines applying Local Wisdom Species (LWS), namely Purun (Eleocharis dulcis Hensch); Sago (Metroxylon sago Rottb); Gelam (Melaleuca cajuputi Powell) and Honeybee, and Gaharu or Agarwood (Aquilaria malaccensis Lamk), to involve rural communities in peatland restoration. If LWS disappear due to pressure from industrial plantations, rural communities will be controlled by the international trade system, which threatens their rural lifestyles, and they will be pushed out of



the peatlands where they have lived for hundreds of years. This research aimed to reveal selected LWS in developing peatland restoration. This study applied field surveys, questionnaires and focus group discussions. Purposive sampling was used to get the data, collected, processed, and analysed. For rural communities, the LWS was developed for economic, technical, social, and environmental reasons. If the government can help rural communities to develop the LWS, then it is likely that rural communities will benefit from better management of peatland restoration. It requires collaborative efforts between rural communities, researchers, and policymakers to bridge traditional knowledge and modern science, encouraging a more comprehensive approach to addressing global challenges. This finding is very useful in participating rural community-based peatlands restoration using four approaches, namely decentralization, conservation, protection and optimization. With these four approaches, it is possible for this research finding to be implemented in the field.

1. Introduction

Within the field of biodiversity conservation and restoration, Local Wisdom Species (LWS) can play an important role. LWS are species saved and safeguarded by local knowledge. A collection of information, values, and customs that have been handed down over the ages is known as local wisdom (Armanto & Wildayana, 2025). LWS refers to species of plants, animals or other organisms that are protected, utilized and respected in cultural and ecological practices based on local wisdom (Armanto, 2019c). LWS often have ecological, economic, social, or spiritual value to the communities that depend on them (Syakina et al., 2024b). These LWS have, however, received little attention in the scientific restoration literature, creating a serious vacuum in the tactics being used for restoration today (Armanto et al., 2025c).

Peatland restoration is an area in which the role of LWS can be significant. Although peatland productivity has increased, there has been increasing degradation, and the poverty problem is still not resolved (Wildayana & Armanto, 2021), especially in rural areas that do not have access to markets. The goal of

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peatland restoration should be to contribute to the elimination of rural poverty by increasing the income of rural communities. Without special efforts that address the main problem of poverty, peatland restoration will not be achieved (He et al., 2023).

The majority of rural communities living on peatlands do not receive adequate attention from government policies aimed at extracting the wealth of the peatlands (Kaban et al., 2024), which leads to uneven development and these communities are especially marginalized in the national political process (Collier and Scott, 2009; Antonoplis, 2023). Select LWS that have historically contributed to the local community's relationship with peatland ecosystems are integrated into our study to offer a new approach to peatland restoration (Zuhdi et al, 2019). Despite being firmly ingrained in regional ecological knowledge and cultural customs; these LWS are frequently disregarded in contemporary restoration projects (Imanudin et al., 2019). By acknowledging these LWS importance, we hope to develop a restoration framework that is more ecologically robust and sustainable, in line with the sociocultural values of the local community and the scientific objectives of ecological restoration (Armanto, 2019b).

The deficiency in the existing research is due to the restricted LWS examination in scientifically supported restoration procedures, as well as the neglect of the socio-cultural aspects of restoration (Armanto et al., 2025d). Few research has examined how these LWS, which are linked to indigenous knowledge, might significantly aid in the restoration of degraded peatlands, despite the fact that numerous studies have highlighted the significance of biodiversity and ecosystem services. Our study fills this gap and adds to the increasing amount of research that acknowledges the importance of local knowledge systems in tackling environmental issues (Syakina et al., 2024a).

Purun (E. dulcis Hensch); Sago (M. sago Rottb); Gelam (M. cajuputi Powell) and Honeybee, and Gaharu or Agarwood (A. malaccensis Lamk) are some LWS found in peatlands and already well-known by rural communities. However, it is very regrettable that all these LWS have almost disappeared (only 10-20% of local commodities retain them) due to government policies granting industrial plantation concessions and most rural communities work in this sector (Armanto & Wildayana, 2023). There is an opportunity to reactivate these LWS with peatland restoration (Yazid et al., 2020). This will reduce peatland degradation and create new sources of livelihood for rural communities (Wildayana & Armanto, 2018a).

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Many experts reviewed the LWS and rural institutions as constraints to growth. This view contradicts this perspective (Wildayana & Armanto, 2018c). The LWS is a body of knowledge, practices, culture and beliefs developed and maintained by rural communities through generations (Armanto et al., 2025a). It discusses many things, such as resource management and farming, health, stories, and spirituality (Armanto et al., 2024; (Holidi et al., 2019).

We hope to make three contributions to the scientific community. Firstly, by including LWS, which have been mostly overlooked in conventional restoration literature, we want to advance our understanding of peatland restoration. Secondly, we want to provide useful advice on how to include local knowledge into peatland restoration plans, with a focus on long-term sustainability, cultural significance, and community involvement. Thirdly, providing guidance for upcoming restoration initiatives, we think our study findings will help advance a more inclusive, culturally sensitive approach to environmental preservation worldwide (Wildayana & Armanto, 2018b).

The idea behind this is sustainable agriculture that uses appropriate technology to fight poverty and protect natural resources and the environment (Armanto, 2019a). This study can support government policy changes aimed at reducing risks associated with agricultural production, increasing productivity, and diversifying crop varieties at the farm level (Byg et al., 2023). This study aimed to reveal selected LWS in developing peatland restoration in South Sumatra, Indonesia.

2. Materials and Methods

Research sites

The study was conducted in the Indonesian province of South Sumatra, which is situated between 1-4° South latitude and 102-106° East longitude (Figure 1) and the entire area of the observed study area as Peat Hydrological Unit (PHU) was 995,756 ha (PMRA, 2022; Armanto et al., 2022). Table 1 provides general descriptions of PHU that have been observed.

Sample selection and selection factors of LWS

Based on LWS significance for peatland restoration, selected species were determined based on a combined method of field surveys and discussions with stakeholders (indigenous farmers, environmentalists, related governments and study literature). A number of field surveys were carried out throughout South

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Sumatra peatlands, paying particular attention to areas that had previously been affected by peatland degradation or were undergoing restoration. We documented the LWS found during the surveys, along with their ecological function and any cultural significance that the local communities may have attached to them. To determine which LWS are prized for their ecological, therapeutic, or agricultural significance, interviews with members of the local community were conducted. This made it possible to guarantee that the sample contained species that were culturally significant.



Figure 1. Research location in South Sumatra province, Indonesia.

The factors served as the foundation for the final species selection: Ecological suitability for peatland restoration (e.g., LWS that are known to promote water retention in peatland ecosystems, stabilize peatlands, or restore biodiversity); significance that the local communities have designated as cultural and customary. For ease of propagation and availability of species for restoration projects, 4 species were selected from the 58 species investigated.

Table 1. General descriptions of observed Peat Hydrological Unit (PHU)

Parameters	Merang- Ngirawan	Saleh- Sugihan	Sugihan- Lumpur	Burnai- Sibumbung
Area, ha	82,021	190,230	636,828	86,679
Burnt area 2019, ha	8,513	29,167	39,786	10,134
Restoration types	Canal blocking, livelihood revitalization	Canal blocking	Canal backfilling and DFG	DPG and 3-R
Targeted	Muara Medak,	All villages in	All villages in	All villages in
restoration, ha	33,104	PHU, 4,766	PHU, 228,378	PHU, 39,445

Note: DPG (Peat care village program); 3-R (rewetting, revegetation and revitalization. Source: Field survey results (2025).

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Resolving selection bias

Even though every attempt was taken to guarantee a representative sample, it is crucial to recognize the possibility of selection bias: Geographic Bias: The species chosen might be skewed toward those in South Sumatra more accessible places, potentially ignoring species located in more isolated peatland regions. Cultural Bias: Species that are less well-known but nevertheless crucial for ecological restoration may be overlooked if the selection process favours those that the local communities consulted are most familiar with or value. Ecological Bias: By concentrating on species that directly contribute to the restoration of peatlands, other species that might also provide ecosystem services but were not given priority in the selection criteria may be left out. We made an effort to incorporate a wide variety of species from various ecological, cultural, and geographic contexts within South Sumatra in order to lessen these biases. However, when interpreting the results, it is important to take into account the limits of the sample selection procedure.

Data analysis

The research data was analysed using the SPSS program. The following are the procedures used in the analysis (Pallant, 2020): Preparing Data: A systematic format of the information gathered from the interviews and field surveys was entered into SPSS. Names of plant species, ecological roles, customary applications, and other pertinent characteristics were among the variables. Descriptive Statistics: To highlight the traits of the chosen species, such as their ecological roles, frequency of occurrence, and significance as judged by local communities, descriptive statistics were conducted. Calculations were made using metrics including mean, standard deviation, and percentages. By include this thorough description in your methodology section, we addressed potential biases and the selection process while also clearly outlining how SPSS was used for data analysis.

3. Result and Discussions

3.1 Differences between the LWS and commercial species in peatlands

Differencing the LWS and commercial species in peatlands can be analysed through three elements, i.e. substantive, methodological, and contextual, as explained in Table 2. The most prominent substantive differences lie in their development history and characteristics, while commercial species aim to build a general explanation and are not based on the daily life of rural communities and

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have a trace of global economic development. However, the LWS is directly related to the needs of rural communities and is created based on daily livelihoods. This finding is in line with another research (Ribeiro et al., 2021).

Variables	LWS	Commercial species
Substance	Friendly with peatlands, passed down through generations	Force peatlands, an adaptation from dry land
Methodological and epistemological	closed system	open system
Knowledge contexts	valid locally	valid universally
Actors	Local rural communities, NGO	Investors, government
Regional development	Low	High to very high
Social conflict	Low	Moderate to high
Species	Purun; Sago; Gelam; Gaharu	Oil palm; Acacia
Peatland degradation	Minimal	Moderate to high
Measured parameters	General	specific

Table 2. Differences between the LWS and commercial species in peatlands

Note: NGO (Non-Governmental Organization). Source: Field survey results (2025).

The methodological and epistemological nature of the LWS is closed, unsystematic, and broad rather than analytical; it lacks a complete conceptual framework and stands on new experiences rather than deductive logic. Much of the LWS approach is dogmatic and intolerant of current knowledge technology and innovation. Meanwhile, commercial species are open, systematic, objective, analytical, and developed from current knowledge technology, and innovation. This finding is similar to other workers (Yan et al., 2023).

The LWS are local and focus on a particular social group, in a particular setting, and at a particular time, but commercial species occur worldwide. At the same time, we can find the same connection in the concentration on the way local scientists or "scientists" produce knowledge. Rather than trying to lump all non-scientific knowledge into the category "local" and all commercial species into another category, it may make more sense to accept the differences within these categories and find commonalities between them. This finding is relevant to another research (Armanto et al., 2023a).

3.2 Key aspects of the learning process of the LWS for rural communities

The research findings were used to discuss key elements of environmental sustainability and rural farming in peatlands, the evolution of agricultural-based systems, the motivations behind cultivating peatlands, and important entry points for reducing poverty and ensuring rural farming. Key aspects of the LWS learning

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process for rural communities are given in Table 3. These findings support research by other workers (Barry et al., 2021).

Table 3. Key aspects of the LWS through generations

Key aspects	Impact of key aspects		Comments
passed down	theory	field facts	
Oral tradition	intensive	indeterminate	Oral delivery should be more dominant because rural communities have learned more from generation to generation
Holistic understanding	low	low	Low education also causes a low holistic understanding
Environmental stewardship	low	indeterminate	This aspect should be low, associated with a low level of education
Spirituality and ethics	intensive	moderate	This aspect is high because it is associated with high religious beliefs
Intergenerational learning	intensive	indeterminate	Intergenerational learning is a necessity in rural communities
Respect for diversity	low	low	Low education has an impact on low respect for diversity

Source: Field survey results (2025).

<u>Oral tradition</u>. The LWS is passed down orally and intensively through stories, songs, and rituals, from parent to child. This dynamic mode of transmission helps preserve cultural heritage and enables the adaptation of knowledge to change circumstances. For example, a traditional leader may paint a picture to convey important lessons or ideas to younger members of a rural community. This way of learning art is very useful when rural communities cannot communicate well due to language barriers. However, due to the influence of technology and globalization, this traditional oral tradition is currently indeterminate. The same finding was also described by other researchers (El Chami & El Moujabber,2024).

<u>Holistic</u> understanding. For hundreds of years, rural communities have understood that all living things and their environments are interconnected. They see the relationships between plants, animals, ecosystems, and humans, and use this knowledge to make decisions about rural life and communities. For example, when rural communities think about how to manage land or water, they consider how it will affect all living things in the area. Unfortunately, holistic understanding by rural communities, both theory and field facts, is still relatively low. The same investigating was also described by other researchers (Hagan et al., 2023).

Environmental stewardship. Sustainable peatlands management methods have been developed by rural communities. Deep understanding of the needs of

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different species and depending on how they interact with each other in a particular environment. This finding is in line with the results of other studies (Zhang, 2023). For example, some species can grow and develop in stagnant water conditions, while other species require a deep groundwater table, which means that it has to be drained. Another example is that while some species require full sunshine, other species require shading. Rural communities have learned how to manage these different needs through careful observation and experimentation, trial and error, or oral traditions passed down from generation to generation to help children understand the importance of maintaining a balanced ecosystem. In theory, understanding of environmental stewardship was low, along with the development of science and technology, the understanding has become indeterminate. The same finding was also described by other researchers (Hinzke et al., 2021a; 2021b).

<u>Spirituality and ethics</u>. Spirituality and ethics include spiritual beliefs and moral rules for living in harmony with nature. These beliefs determine the way how rural communities deal with their environment. For example, many native cultures believe that humans and nature have a sacred bond. Their spiritual connection encourages them to treat the LWS carefully. For example, they used their skills to manage peatlands wisely, allowing them to continue living sustainably without harming the environment. Another example is they made drainage channels not too deep so that the peatlands are not disturbed. They believe that if drainage channels are too deep, it will dry out the peatlands, making the peatlands vulnerable to fire, which threatens their life. Unfortunately, their spirituality and ethics are theoretically intensive, but the field facts show that they are currently moderate. This finding is in line with the results of other studies (Jing et al., 2020; Lin et al., 2020).

Intergenerational learning. Intergenerational learning is essential to sustaining culture. By passing down their knowledge through oral traditions, elders were able to preserve stories, songs, and customs to grow with nature. Intergenerational learning about the conservation of the LWS as traditional medicine and spice species is very clear. Due to globalization and assimilation into larger cultures, many traditional medicines are being lost. It means losing our history and traditions too. In theory, intergenerational learning was intensive, and along with the development of science and technology, intergenerational learning becomes indeterminate. This finding is in line with the results of other studies (Wildayana & Armanto, 2017).

<u>Respect for diversity</u>. The LWS is site-specific and varies depending on location and time. Each community has knowledge adapted to its own situation and

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cultural heritage. One example is slash-and-burn farming which uses fire to manage peatlands. They burn the peatlands at different times and places throughout the year (in 5–10-year cycles), so that certain plants grow best, and certain animals find food more easily. They also help maintain the health of ecosystems for plants and animals. However, peatland degradation will be accelerated when the peatland burning cycle is shortened, only every year and in the same location. The LWS is increasingly recognized as beneficial in many areas, such as environmental conservation, sustainable development, and climate change adaptation. In fact, both in theory and in field facts, their respect for diversity is indeed low to date. This finding is in line with the results of other studies (Michaelis et al., 2020).

3.3 Selected LWS adapted by rural communities

LWS refers to species that are important in local culture and ecology and preserved through traditional wisdom. This concept shows how rural communities have an important role in protecting the environment through practices based on knowledge passed down from generation to generation. The relationships between local knowledge, LWS, and ecological interactions in local community are summarized in Table 4.

Relationship	Ge	neral description			
	1)	Rural communities often have intimate knowledge of the lying			
Species and local		species in their environment.			
knowledge	2)	This knowledge includes the use of species for medicinal, food, or			
		ecological purposes, as well as an understanding of those species.			
Sustainable interaction	1)	Interactions between humans and LWS can occur in the form of non-			
		destructive uses, such as sustainable hunting, agroforestry farming,			
		sonor system, or culturally based conservation practices.			
	2)	This practice allows LWS to survive and thrive, while providing			
		benefits to humans.			
	1)	Refers to LWS that are part of the traditional knowledge of rural			
LWS		communities, so that rural communities can be an example in			
		maintaining ecological balance through local wisdom-based practice			
	that enable harmonious interaction with LWS.				

Table 4. Relationships between local knowledge, species and ecological interactions

Source: Field survey results (2025).

Rural communities still use the LWS in peatland management and conservation, although in limited quantities. They still choose the selected LWS based on the fact that the selected LWS meets the following reasons, namely they are still in the village, have knowledge of better cultivation methods, and have a better future as a new source of livelihood. This finding is in line with another research

(Armanto et al., 2018). The passed-down method for selected LWS learning through generations is summarized in Figure 2.



Figure 2. The learning method for passing down the LWS through generations

<u>Purun</u> (*E. dulcis Hensch*). Rural communities use Purun as the main material to make woven household industries, such as mats, baskets, bags, hats, and table mats to maintain family income and protect the peatlands environment. They know more about their life in peatlands because of their dependence on this type of livelihood. Based on environmental sustainability parameters, Purun shows very strong dominance in terms of oral tradition spirituality and ethics, while other aspects are relatively moderate. At present, they are still managing Purun, but the threat of extinction arises because Purun is little known to the younger generation, and this fact is exacerbated by the use of plastic as a substitute material.

Sago (*M. sago Rottb*). Sago belongs to native peat species producing starch and carbohydrates, thus it is utilized as the staple food of rural communities and used for revegetation species for peatlands (also known as paludiculture). After being ground into powder, the pith of sago stems contains starch. The powder is kneaded with water on a cloth or sieve to release the starch. The tub where the starch lands receive the starch water flow. It is now possible to utilize the starch for cooking after multiple washings. Each palm tree can yield roughly 360 kg of dry starch. Sago flour can be used to make various types of food, such as sago pudding which is formed into balls and mixed with boiling water to form a paste

such as pancakes, *pempek*, and glue. Sago flour is a food ingredient native to South Sumatra. Real sago flour is pale white, uneven, and brittle, and cooks quickly compared to tapioca flour. Based on environmental sustainability parameters, Sago holds a strong presence in oral traditions, spirituality, and ethics, while knowledge of its other aspects remains relatively limited. Sago is also hardly popular among the younger generation. This is because there is tapioca flour as a substitute for sago flour.

Gelam (*M. cajuputi Powell*) and Honeybee. Gelam consists of two species, namely M. leucadendra and M. cajuputi, and M. cajuputi has the highest essential oil content and has the greatest potential. Gelam flowers, or Melaleuca cajuputi, are loved by honeybees because they produce good honey. Currently, honey production is only carried out on a small scale and for subsistence purposes, but since honey is an export product, there is a clear scope for its production. Food is considered to have medicinal value. Gelam flowers are abundant throughout the year and produce copious amounts of nectar, making them an ideal host species for honeybees. Per hectare of Gelam can be harvested around five to six litres of honey each year. In rewetted and revegetated peatlands, beekeeping and honey production are viable options. The domestic demand for honey every year is 7,500 tons, but production is only 2,000-4,000 tons, and the rest is imported. Based on environmental sustainability parameters, Gelam shows strong dominance in the aspect of oral tradition, spirituality, and ethics, as well as respect for diversity, while other aspects are low to moderate. Gelam is known to the younger generation but less understood for paludiculture.

<u>Gaharu</u> (*A. malacensis Lamk*). Agarwood (Gaharu) is a woody spice containing aromatic resin which is used as a mixture of incense, perfume, and industrial raw materials. Aloes are produced by plants in reaction to microorganisms getting into damaged tissue. Broken branches or peeling bark can become natural wounds on woody plants. Once microbes enter plant tissue, they are considered foreign bodies. As a result, plant cells produce phytoalexin compounds, which protect plants from disease or pathogens. The phytoalexin compound is a brown resin with a pleasant scent that can build up in the xylem and phloem channels to stop wounds from spreading to other tissues. Aloes won't form and damaged plant parts may decompose if the bacteria that infect the plant manage to get past its defence mechanism.

Agarwood has a higher price if the resin content is higher, and vice versa. Agarwood is generally offered in three main classes, namely ash, sapwood, and *kemenyan*. Sapwood is a dark brown or brownish-black wood derived from the agarwood tree strongly masticated sections. Kemenyan is agarwood with coarse fibre, softwood, and a brownish-to-grey physical colour. The last class is agarwood ash. According to environmental sustainability parameters, Gaharu shows very strong dominance in terms of spirituality ethics, and oral tradition, meanwhile, other aspects are relatively low. Gaharu is also almost not popular with the younger generation. This is more difficult because Gaharu is not cultivated well by rural communities.

3.4 Determinant reasons for implementing selected LWS

Selected LWS relates to environmental sustainability indicators. Holistic understanding; oral tradition; environmental stewardship; spirituality and ethics; intergenerational learning; and respect for diversity are several indicators of environmental sustainability The results of these findings support research by other workers (Lázaro-Lobo et al., 2023). Based on the explanation of their selected LWS learning process in the paragraph above, scoring was carried out to determine shifts in the learning process based on a comparison of theory and field facts as shown in Figure 3.



Figure 3. Learning processes of the LWS for rural communities

In theory, the LWS overgeneration learning process was dominated by aspects of intergenerational, spirituality, and ethics, as well as oral tradition with scores

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of 95, 90, and 80 respectively. Meanwhile, the lowest was related to understanding the environment and science, namely holistic understanding with a score of 20, and respect for diversity is 10. However, the field facts showed that everything changed and was dominated by indeterminate conditions which were categorized for the spiritual aspect, which was 60, oral tradition was 40, and intergenerational was 40. The lowest scoring was shown by a holistic understanding of 25 and respect for diversity, namely 15.

Furthermore, the research results showed that the dominant contribution of each determinant reason to the LWS application was fully presented in Table 5. The LWS for agricultural production are called rural farming showing how closely the LWS was connected to the basic needs of rural communities in the peatlands. To meet their family's food needs, rural communities experience various difficulties in developing their agriculture. Even though the results were low and required high work intensity, they still applied LWS in managing their agriculture. The results of these findings were relevant to our previous results (Wildayana, 2017).

Nr	Determinant reasons	Purun	Sago	Gelam/ Honeybee	Gaharu
1	Economic reasons	36	51	36	36
	Price fluctuation	15	20	15	15
	Circumstancing the famine months	13	20	13	13
	Low labour and opportunity cost	8	11	8	8
2	Technical reasons	31	26	30	30
	Soft skill	17	15	17	20
	Government supports*/	10	10	9	8
	short-lived species	4	1	4	2
3	Social reasons	20	10	20	20
	Customs	10	4	10	10
	Institutional aspects	6	3	6	6
	Social accessibility	4	3	4	4
4	Environmental reasons	13	13	14	13
	Peatland vulnerability	5	5	6	6
	Preference for ethnic minority	4	4	4	4
	Land suitability**/	4	4	4	4
	Total	100	100	100	100

Table 5. Contributing determinant reasons why rural communities apply the LWS (%)

Note: */ Helping *saprotan* (agricultural production equipment) **/ other land uses both in the agricultural sector and other sectors. Source: Mainly survey results (2025).

There are four determinant reasons, namely economic reasons which played a role between 36-51%, technical reasons which accounted for 26-31%, social reasons 10-21 %, and environmental reasons between 13-14%. It turns out that economic factors and technical reasons played an important role in implementing

the LWS. From Table 5, there are three opportunities open up: 1) in this peatland restoration program, rather than forcing rural communities to cultivate not native peat species, the government should support the LWS to be developed; 2) Corporate Social Responsibility (CSR) programs from industrial plantations can be focused on developing the LWS so that rural communities can earn extra income; 3) As we realize that industrial plantations cannot guarantee replanting after 25 years of planting (one planting cycle) because Oil palm and Acacia require excessive drainage. Meanwhile, the LWS is the only opportunity for them to survive in the peatlands.

Economic reasons. The LWS Sago showed the most significant economic reasons (51%), followed by Purun, Gelam, Honeybee, and Gaharu (average 36%). Price fluctuations, circumventing the months of poverty, low labour costs, and opportunity costs are the main economic factors. Uncertain agricultural market conditions will make farms very risky and difficult to tolerate if they depend on the market to meet their needs. Rural communities develop agriculture as a subsistence crop that is high in carbohydrates for various reasons, one of which is to reduce the risk of agricultural price fluctuations. Additionally, due to inefficient food markets, poor agricultural productivity, and high transportation costs. Producing food on large tracts of agricultural land, especially remote peatlands, is one way to reduce these agricultural risks. The same finding was also described by other researchers (Armanto et al., 2025b).

Community members wanted to avoid months of famine, which influenced their decisions to expand their farms. Currently, food supplies are decreasing due to rising debts, assets being sold, peatlands degradation, especially during the dry season, and most household members working to diversify their income or migrating. Some members of ethnic minorities, including rural communities, are looked down upon by society and are trapped in a cycle of poverty. The two main factors that perpetuate and exacerbate poverty are food insecurity (inside the circle) and agricultural instability (outside the circle).

Agricultural fields are usually formed by intensive farming systems to spread the use of labour over a longer period and prevent labour bottlenecks. Family employment costs are expected to be low in peatlands with limited market accessibility due to limited employment opportunities, both agricultural and non-agricultural. Producing agricultural products for subsistence using family labour and land would be more economically profitable than purchasing agricultural products on the open market under such circumstances. Rural communities also do not have enough money to meet their needs, so buying food from agricultural markets is impractical for them.

<u>Technical reasons</u>. Technical factors (contributing 30-31%) include their soft skill components, government support, and short-lived species, except for the LWS Sago. Having these soft skills will help them grow crops and be able to control the availability and need for water according to the requirements of the plant's growth period. There is very little planned, measurable, and systematic support provided by the government to them to expand their agricultural businesses. To encourage them to continue producing agricultural products in the peatlands, government support is very important. Agriculture does not require a long waiting period to harvest its products, as the harvest time is shorter compared to other annual crops. In most peatlands, they can plant more than twice a year if soil water conditions can be controlled. The growing season is usually less than four months. This finding is in line with other workers (Armanto & Wildayana, 2022).

<u>Social reasons</u>. Sago showed the lowest social reasons (10%) compared to other contributing commodities (average 20%) including customs components, institutional aspects, and social accessibility. Rural community customs play a significant role in rural communities applying the LWS because only with the LWS can rural communities believe that their agricultural business will be successful.

The marketing of agricultural products is a very dominant institutional factor that influences rural communities' decisions to use the LWS. In poverty-prone areas, weak marketing infrastructure and remote locations prevent residents from participating in any activities and taking advantage of broader economic progress. Most peatlands have the above-mentioned characteristics of poverty. Rural communities around peatlands often experience food insecurity and poverty, especially in remote and difficult-to-access areas. Poverty is more common in remote peatlands.

External cycles that destroy environmental resources are triggered by an increase in population that puts pressure on land resources. If peatlands are planted more frequently without appropriate technology, environmental resources will become more fragile. This reduces land production while maintaining or even stopping the cycle of poverty. The cause of the second cycle, or deep cycle, maybe the inability to participate in earnings. This is because rural communities live in remote areas without adequate infrastructure and have limited access to markets. Since subsistence farming requires rural communities to dedicate much of their land and labour resources to meet their basic food needs, they have fewer resources available to pursue other profitable employment opportunities.

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Agriculture plays an important role in meeting the family's food needs during the "dry season lean months", which usually occur in September or October, when the previous year's food stocks have run out and the peatlands have not been harvested. Agricultural land plays a role in overcoming the food supply deficit during these crucial months. Hence the importance of "trap" agriculture, where agriculture grows simultaneously with commercial crops such as rubber and oil palm. During October and November, agriculture grows in proportion to overall consumption, which eventually becomes the leader. Similar findings have also been described by other researchers (Wildayana & Armanto, 2018d).

Environmental reasons. In general, rural communities do not pay attention to environmental reasons in applying local wisdom, it has been proven that the contribution of this factor is relatively small, around 13-14%. These reasons are expressed in the form of peatland vulnerability; preference of ethnic minorities; and land suitability. This parameter is used to describe environmental characteristics. Rural communities can gain profits from their agriculture if rural communities find peatlands that are suitable for farming. The results of these findings support research by other workers (Armanto et al., 2023b).

Currently, peatlands account for about 25% of agricultural products. Production of agricultural products is part of the rural communities' livelihood system, especially for those who have limited access. Agricultural products in the peatlands ensure the survival of most ethnic minority groups, especially Javanese. Some ethnic minorities still farm, despite a highly market-oriented and marketized production system. The LWS practices are considered better than other farming methods in many cultures. This result was relevant with findings by other workers (Armanto et al., 2017).

According to field data, conflicts arose between industrial plantations and indigenous farmers, especially around the management of peatland restoration. Four approaches are recommended for sustainable peatland restoration based on local knowledge, specifically:

 The decentralized approach, which consists of marketing, linkages, participation, administration, and authority delegation. Its characteristics include community empowerment, site uniqueness, and commodity zoning. This can be accomplished, for instance, by using technology to benefit stakeholders, beneficiaries, and the environment while cultivating LWS in compliance with the revitalization program.

- 2) The conservative approach, choosing a business plan that is anticipated to generate greater profits over time, even if it seems less profitable in the short term, is the conservative approach. For example, the Gelam and honeybee colonies do not need peatlands to be drained.
- 3) The protective approach that involves preserving peatlands whose ecological advantages surpass their potential for profit and complements initiatives for ecological restoration, including sago cultivation. Sago does not require the draining of peatlands.
- 4) The ideal approach. It is possible to cultivate Purun for household industry, which is the greatest way to manage peatlands based on the quantity, quality, and duration that are most advantageous and sustainable.

4. Conclusions

In South Sumatra, Indonesia, the potential of a few chosen LWS as a basis for long-term peatland restoration are Purun (*E. dulcis Hensch*); Sago (*M. sago Rottb*); Gelam (*M. cajuputi Powell*) and Honeybee, and Gaharu or Agarwood (*A. malaccensis Lamk*). According to our study, some LWS that are ingrained in the local ecological knowledge show a high degree of tolerance to peatland conditions, help preserve soil and water and provide local communities with cultural and economic benefits. In addition to boosting ecological resilience, these LWS aid in community-based restoration initiatives that respect regional customs and means of subsistence.

Our study does, however, have a number of limitations. First of all, it was restricted to particular locations of South Sumatra, which would not accurately reflect the variety of local knowledge found in the larger peatland areas. Second, qualitative and semi-quantitative methodologies were used to evaluate the ecological performance of chosen species; longer-term, empirical field trials could be beneficial. Finally, although taken into account, socioeconomic effects and stakeholder viewpoints need more investigation to produce stronger policy suggestions.

Although these limitations, the study has encouraging consequences for upcoming peatland restoration initiatives. Integrating local species with local knowledge offers a restoration strategy that is both environmentally sound and culturally appropriate. Strategies for participatory development, conservation policy, and landscape planning can all benefit from the findings. To further understand the trade-offs and co-benefits of restoration paths including local

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wisdom species, future research should concentrate on long-term monitoring of species performance, scaling up trials in various peatland zones, and integrating socio-economic models.

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Mountain Therapy as a support in breast cancer treatment.

A pilot study in Southern Italy

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Keywords: natural-based intervention; mountain therapy; breast cancer; environment.



Abstract. This paper offers a pilot study on Mountain Therapy (MT) as a therapeutic-rehabilitative and/or socio-educational methodological approach aimed at the secondary prevention, treatment and rehabilitation of people with different pathologies. The study was conducted in 2021 in the Sila National Park in the Calabria region (Southern Italy) and involved a group of 19 breast cancer patients after surgery, chemotherapy and radiotherapy. The main results show that the patient's quality of life improved after the MT approach, reducing stress and anxiety levels. These effects were measured by the submission of the HADS - Hospital Anxiety and Depression Scale - questionnaires at time 0 (start) and time 1 (end) of the treatment and by an NCCN Distress Thermometer. The study confirms the regenerative capacity of the natural environment in people suffering from a disabling disease, monitored through the assessment of psycho-physical parameters, helping to improve their quality of life and reduce hospitalisations.

1. Introduction

Several studies have shown that a genetic predisposition can influence an individual's risk of developing chronic diseases (Jukarainen et al., 2022; Wehby et al., 2018). In addition, external or environmental factors such as diet, lifestyle and climatic conditions may also lead to an increasing number of nontransmissible diseases (Frumkin & Haines, 2019; Pichler et al., 2022), mainly due to the negative impact of urbanisation and anthropisation of ecosystems on a global scale (Guagliardi, 2022). Aside from the progress of medical research in treating and preventing several diseases, growing scientific evidence shows that the natural environment has great potential for disease prevention and health promotion (Gladwell et al., 2013; Martin et al., 2020; Mitchell and Popham, 2008). Natural environments, such as forests or urban green spaces, are incredible resources that have a great impact on human health. The relationship between natural environments and psycho-physical well-being is one of the benefits classified as ecosystem services. These are defined in the Millennium Ecosystem Assessment (2005) as "multiple benefits that ecosystems provide to humanity". The positive effects of green spaces on human mental and physical

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health, both in terms of prevention and treatment, have been extensively documented in the scientific literature since the 1980s and continue to be tested today (Anundi et al., 2023; Cerulli et al., 2014; Kondo et al., 2018). The influence of the environment on people's well-being and psycho-physical recovery was first investigated in studies with patients, particularly hospitalised patients and elderly people visiting healthcare facilities (Gross et al., 1998; Ulrich, 1984). Direct exposure to urban and non-urban green spaces brings various psychological, cognitive, social and spiritual benefits (Ricca and Guagliardi, 2015, 2023). The hypothesis is based on the fact that biophilia (Wilson, 1984) has a regenerative capacity and an "innate tendency to focus interest on life and vital processes". This regenerative capacity of natural environments has also been illustrated by Stress Reduction Theory (SRT, Ulrich, 1981; Ulrich et al., 1991), according to which a non-threatening natural environment or the sight of natural elements can activate stress reduction, support key indicators central to discomfort response such as blood pressure and heart rate, improve mood and induce relaxation. More frequent and longer stays in green spaces have a more substantial and lasting effect than isolated and shorter stays (van den Berg et al., 2017). The importance of daily contact with the nearest green spaces for psychophysical health has also been demonstrated by studies conducted during the COVID-19 pandemic, with people forced to stay home (Fari et al., 2023; Gola et al., 2021; Noszczyk et al., 2022).

The subjects who could observe trees and green spaces from their windows or visit nearby parks and even community gardens reported lower rates of depression and anxiety (Marselle et al., 2020; Vivona et al., 2021). On the physiological side, very significant effects were observed in improving cardiovascular functions and hemodynamic, neuroendocrine, metabolic, immunological, inflammatory and oxidative indices (Song et al., 2016).

Among the several nature-based health interventions, forest and mountain therapies are emerging as potential alternatives to complement or replace other forms of treatment (Robinson and Breed, 2019). Forest therapy (FT, Karjalainen et al., 2010; Li, 2018; Schuh and Immich, 2019; Shin et al., 2010) encompasses the activities undertaken by individuals and groups in forests - and other natural or semi-natural environments such as landscaped gardens and urban green spaces - to achieve mental and physical health and other well-being outcomes. Several authors believe that mindful, multi-sensory, immersive contact experiences with nature are particularly likely to promote positive health outcomes, from psychological stress reduction and mood enhancement to physiological improvements with increased parasympathetic activity. FT plays an essential role

in physical recovery (Stigsdotter et al., 2017) but can also have a positive effect on blood pressure (Mao et al., 2017) and heart rate (Ikei et al., 2015). Moreover, FT can be used to reduce risk factors for cardiovascular disease (Mao et al., 2018). Depression (Shin et al., 2012), exhaustion (Sonntag-Öström et al., 2015) and sleep disorders (Morita et al., 2011) can also be positively influenced by spending time in a forest environment.

A systematic analysis of the literature on the effects of green spaces on health (Wolf et al., 2020) shows that 41% of the studies concern the reduction of harm both in terms of harmful effects (air pollution, ultraviolet radiation, exposure to pollen) and benefits (ability of trees to reduce greenhouse gases, mitigation of heat). Another 31% of the studies concern the psychological and cognitive areas, the restoration of mental health and the reduction of stress and anxiety. 28% of the studies relate to improving well-being in terms of active living, physical activity, strengthening the immune system and improving cardiovascular function. Notably, the studies listed in the above review mainly focused on the effects of healthy individuals or people with non-disabling conditions staying in the natural environment. A particular type of FT that can be found in therapeutic interventions in mountain environments is mountain therapy (MT). It has been documented that MT can enhance the effects of being in a natural environment by combining the benefits of green spaces with the benefits of mindfulness, climate therapy and occupational therapy (Huber et al., 2023; Pichler et al., 2022). In particular, MT has been shown to help cancer patients recover during and after the specific medical treatments their disease requires. Over the past ten years, the literature has examined the effects of exposure to the natural environment on the psychophysical well-being of cancer patients and survivors. According to the World Health Organization, cancer is the leading cause of death worldwide, with nearly 10 million victims in 2020, and early diagnosis and treatment remain the most important ways to reduce mortality. Experiences in nature, especially in the forest, can be a powerful intervention to create a potentially safe space for cancer survivors, as they facilitate a connection to self and strengthen the ability to address health needs (Park et al., 2022). The natural environment of the mountains is an important background for a therapeutic path that reactivates both the motor and cognitive dimensions, which is rediscovered through movement, fatigue and contact with the multisensory stimuli that the mountains offer. In addition, thanks to the silence and moments of solitude, patients rediscover their inner selves and share their feelings collectively with the other group members. Spending time in nature has a positive effect on the cancer-related quality of life and impacts immune system markers such as natural killer cells and T cells, cortisol and anxiety levels (Bikomeye et al., 2022). Another

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systematic review of the literature on the effects of exposure to nature on cancer survivors (Timko Olson et al., 2023) reveals that studies were conducted mainly in the United States, Canada, Australia, New Zealand, Sweden, the Netherlands, Iran, South Korea and Japan as of 2018. Study participants were predominantly female (approximately 81%), had an average age of 50.4 years, and had breast cancer as their primary disease. The experimental interventions involved walking, resting or relaxing in the fresh air, FT/MT activities and immersive experiences in nature. At the same time, some studies tested seeing and hearing nature using virtual reality devices.

The researchers developed standardised questionnaires to collect qualitative and quantitative data on the effects of spending time in nature on anxiety, stress, depression, pain, fatigue, sleep, quality of life, and mental well-being.

In this perspective, in this paper, we present and discuss the results of a study conducted from June to October 2021 by the Annunziata Hospital in Cosenza (Italy) and the Cosenza chapter of the Italian Alpine Club (CAI), in collaboration with researchers of the University of Calabria (Italy), the University of Magna Graecia (Italy) and the Institute of Mediterranean Agricultural and Forestry Systems (ISAFOM) of the National Research Council (Italy). The study aims to evaluate the effects of MT interventions in the Sila National Park (Italy), a protected natural area recognised as part of the UNESCO heritage, on the psychophysical features of women with breast cancer. Although recognizing the limitations imposed by a small sample size, the present study aims to explore the potential role of mountain therapy in supporting health and rehabilitation. It does not seek to draw broad or definitive conclusions about the effectiveness of such interventions in a quantitative sense. Instead, it represents a pilot study, with the primary objective of developing a methodological framework to study, analyze, and measure whether - and how - mountain therapy may contribute to patient well-being. By focusing on this approach, the study provides a foundation for more extensive, future research in this emerging area of therapeutic practice.

The paper is organised as follows. In Section 2, the materials and methods used in the study are described. Section 3 presents and comments on the main empirical results. In Section 4, a discussion of the theoretical and methodological implications of the study is developed. Section 5 concludes the work with some final remarks, highlighting limitations and future developments.

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2. Materials and Methods

2.1 Geological, geomorphological and climatic setting of the study area

The whole area involved in the study is in the Sila Massif (Figure 1), in the centralnorthern sector of the Calabria region (Italy), where a complex geodynamics environment occurs (Iovine et al., 2018).



Figure 1. Study area location.

The Calabrian tectonic system is controlled by two major transversal structural formations dividing the crystalline rock from the Southern Apennines chain (Sangineto lines) and Maghrebide chain (Taormina line), containing the Calabrian-Peloritani area characterised by structures with covering layers (Guagliardi et al., 2016). From a geological point of view, the Sila Massif represents a batholith constituted by late Hercynian intrusive rocks, prevalently paragneiss, biotite schists and grey phyllitic schists, and Paleozoic medium- to high-grade metamorphites. They have heterogeneous texture and composition from gabbro to leucomonzogranite, with prevailing tonalite and granodiorite (Gaglioti et al., 2019), on which Mesozoic and Miocene to Quaternary sedimentary terranes have imposed. Pliocene sediments represent these last, generally light brown and red sands and gravels, blue-grey silty clays with silt interlayers, Pleistocene to Holocene alluvial sands and gravels and very small outcrops of Miocene carbonate rocks (Guagliardi et al., 2021, 2022). The Sila

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Massif is geomorphologically defined by the Sibari Plain and the final part of the Crati River to the north, the valleys of the Crati and Savuto Rivers to the west, the Lamezia Terme Plain, the Amato River, the Sella di Marcellinara and the Catanzaro Ionian coast to the south, and the Marchesato and the Crotone and Cosenza Ionian coast to the east (Infusino et al., 2022). Its climate is typically Mediterranean but, considering the Sila Massif orography, the area is differentiated by altitude, and it also shows an Apennine Mountain climate (cold continental) with cold and snowy winters and warm summers (Buttafuoco et al., 2016). Precisely, the Tyrrhenian side is influenced by western air currents, which causes milder temperatures and higher precipitation amount on the mountains than on the Ionian side, which is affected by warm air currents coming from Africa (Buttafuoco et al., 2018). The drought period is short, and particularly heavy rains are recorded from October to March, while frost can occur from September to May. The same geological, geomorphological and climatic features characterise all four mountain hikes.

2.2 The mountain hikes

The mountain hikes were carried out in four locations: Righio-Ariamacina, Carrumanco, Cupone (Nordic Walking), Pietra dell'Altare, all of which are in the Sila Massif in the Calabria region (Italy). The selection criteria for the mountain hikes considered physical factors such as topography and accessibility, as well as travel time, trail length, and elevation changes. The goal was to ensure that the hikes would not be physically demanding for the participants. A detailed description was prepared for each trail, focusing on the geographical and environmental features, weather conditions, and its main structural characteristics (Table 1).

The Righio-Ariamacina trail: The Righio–Ariamacina trail traverses a managed black pine (*Pinus nigra laricio*) forest, approximately 30 years old, characterized by sparse undergrowth and well-defined paths. The route passes through ecologically diverse areas that support a variety of plant and animal species, including squirrels, deer, and birds such as the nuthatch (*Sitta europaea*) and chaffinch (*Fringilla coelebs*). Open meadows along the trail are rich in native herbaceous species, including legumes, fescue, chamomile, thyme, and orchids. The mix of forest and open landscapes offers varied environmental stimuli, making this route suitable for observing participant responses to different natural settings. Its accessibility and range of ecological features make it a valuable setting for evaluating nature-based therapeutic interventions.

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		Trail		
	Righio-Ariamacina	Carrumanco	Cupone	Pietra
Date	2021/06/06	2021/09/05	2021/09/12	2021/10/17
Latitude	39.317310	39.24629	39.386108	39.24629
Longitude	16.546793	16.52937	16.547951	16.52937
Altitude (m)	1400	1646	1143	1484
Length (km)	7.0	4.6	7.0	2.4
Travel time (hh:mm)	04:00	03:00	04:00	02:00
Wildlife presence	Y	Υ	Y	Y
Weather (on trail day)	Clear sky	Few clouds	Clear sky	Few clouds
Waterways/lakes	Υ	Υ	Υ	Υ
Refreshment points	Ν	Ν	Y	Ν
Trail surface	Natural	Natural	Dirt	Natural

Table 1. Description of the four trails used in the MT intervention.

The Carrumanco trail: Following the contours of the Sila Massif, this trail alternates between mixed forests and open agricultural landscapes. Tree cover includes pine, beech, and hazel, providing shaded environments and microclimatic variation. Proximity to watercourses introduces riparian vegetation, such as alders and willows, contributing to sensory diversity. Shrublands with species like juniper and heather are present in drier, more exposed areas. The diversity of land cover types along this trail supports the investigation of how different environmental contexts may influence psychological or physiological responses in participants, especially in relation to landscape variety and perceived naturalness.

The Cupone trail: Located near the Sila National Park visitor centre, the Cupone trail covers approximately 7 km with a 500 m elevation gain. It traverses both natural and reforested stands of black pine, beech, and holly, with a structurally complex undergrowth including mosses, ferns, and flowering plants. The trail provides a semi-challenging terrain suitable for studying physical engagement and effort in natural environments. It also offers panoramic views of Lake Cecita and surrounding mountains, presenting opportunities to assess the potential restorative effects of expansive natural vistas. Its mix of ecological richness and physical challenge aligns with objectives to evaluate the multifaceted impacts of mountain-based therapy.

The Pietra dell'Altare trail: This trail progresses through dense coniferous and beech forests, with varied canopy structures and undergrowth compositions. A nearby stream introduces auditory and thermal variability, while the riparian vegetation adds to the habitat complexity. Transitions from conifer to broadleaf forest allow for comparative assessments of environmental perception and therapeutic impact. The gradual elevation gain leads to viewpoints over an artificial lake, which may contribute to mood regulation and cognitive restoration. The combination of immersive forest environments and scenic views makes this trail particularly suited to exploring the psychological and physiological effects of nature immersion.

2.3 Study setting

A pilot study is a crucial preliminary step in research, helping to ensure that the full-scale main study is feasible, methodologically sound, and effective. In the case of the proposed MT study for breast cancer patients, the pilot is essential for several reasons. First, it tests the intervention's practical aspects, ensuring that the participants - who are recovering from surgery, chemotherapy, and radiotherapy - can physically handle the mountain hikes. This step is important to confirm that the intervention is safe and feasible for this vulnerable population. The pilot study also allows us to refine the research tools, ensuring that these instruments accurately measure the intended psychological outcomes like anxiety, depression, and stress. Thus, any issues with these tools can be identified and corrected before the full study. Moreover, the pilot provides early data showing if MT positively affects the participants' mental well-being, offering initial evidence of its potential efficacy. This information is vital for justifying a larger study, showing whether the intervention may improve psychological health. Finally, the pilot reveals potential challenges, such as participant dropout, and allows the research team to address these issues before scaling up. It also helps to confirm that ethical considerations - such as the consent process and participant monitoring - are adequately handled.

For the reasons mentioned above, we decided to perform an initial test on a small sample of patients, analyse the results, and report on all the experiences in the design of the main study.

2.4 Data collection and analysis

The study aims to test the effects of MT on patients with breast cancer, considering the impact of the intervention on the physical and psychological side. The inclusion criteria considered adult women diagnosed with breast cancer

undergoing surgery or post-treatment (chemotherapy and radiotherapy) at the Oncology Multispecialty Unit (OMU) of the Annunziata Hospital in Cosenza (Italy). The study was conducted by observing the well-being of patients, some of whom were members of the Italian Alpine Club. Patients with signs of stress, sleep deprivation or other problems who are judged capable of participating in a group MT activity were asked to participate. The exclusion criteria are physical and/or psychological inability to participate in the intervention. OMU staff recruited suitable participants through direct contact. In addition, advertisements were placed in the clinic to reach other potential participants. The patients were recruited during the post-therapeutic phase and joined the study by signing a consent form. A physician specialising in cancer made the final assessment of eligibility. The methodological approach was based on quantitative data analysis using validated instruments and structured interviews. The effectiveness of the intervention was evaluated using different questionnaires to assess the main sociodemographic characteristics of the patients, the Italian version of the EORTC QLQ-C30 questionnaire to determine the quality of life of participating patients (Fayers et al., 2001a; Fayers and Bottomley, 2002), the Italian version of the National Comprehensive Cancer Network's Distress Thermometer (NCCN DT) (Civilotti et al., 2020; Grassi et al., 2009) to screen patients for distress and the Italian version of the Hospital Anxiety and Depression Scale (HADS) questionnaire (Costantini et al., 1999; Snaith, 2003). The EORTC QLG Core Questionnaire is a 30-item (Physical, Role, Emotional, Cognitive, Social) and eight symptom scales/items (Fatigue, Nausea/vomiting, Pain, Dyspnoea, Insomnia, Appetite loss, Constipation and Diarrhoea) instrument meant to assess some of the different aspects that define the quality of life of cancer patients (Aaronson et al., 1993). All EORTC QLQ-C30 scale scores range from 0 to 100, with a high score on a functional scale indicating a high level of functioning and a high score on a symptom scale indicating a high level of symptomatology (Fayers et al., 2001b). The NCCN definition of distress is "a multifactorial unpleasant emotional experience of a psychological (cognitive, behavioural, emotional), social, and/or spiritual nature that may interfere with the ability to cope effectively with cancer, its physical symptoms and its treatment". Distress extends along a continuum, ranging from common normal feelings of vulnerability, sadness, and fears to problems that can become disabling, such as depression, anxiety, panic, social isolation, and existential and spiritual crises (NCCN, National Comprehensive Cancer Network, 2010). The NCCN Distress Thermometer (DT) is a one-line, 11-point Likert scale displayed on a visual graph of a thermometer, ranging from 0 (no distress) to 10 (extreme distress), which patients use to indicate their distress during the week preceding the assessment.

Patients who report a high level of distress may be given the accompanying 40item Problem List (PL), which lists common problems associated with cancer. Providers can use this PL to identify whether the patient has practical, family, emotional, spiritual/religious or physical problems (Psychosocial Distress Practice Guidelines Panel, 1999). A high score on a problem scale indicates a high level of the specific problem or concern. The HADS questionnaire is divided into two subscales relating to symptoms associated with anxiety and depression. The total score for each subscale ranges from 0 to 21, with a cut-off point of 11 for both scales to divide the sample into those with a balanced to mild level of anxiety and depression (normal) and those with a moderate to severe level of anxiety and depression (elevated). We set T0 as the baseline time point and give patients the self-administered paper questionnaires, asking them to complete and return them at least one week before the program start. In a pretest-post-test design, we asked patients to complete and return the same type of questionnaire after the intervention (T1). The OMU recruited 19 volunteers at the end of May 2021. The Italian Alpine Club organized four walks in collaboration with the ONCOrosa Voluntary Association between June and October 2021. After the testing period, there were 15 valid cases, as three participants withdrew from the study for personal reasons, and one withdrew due to medical conditions. Descriptive statistics were used to analyse the study sample. A two-tailed paired t-test was conducted to assess whether there was a difference between the baseline and follow-up measures. The hypothesis is that over time, patients experience improved quality of life, reduced depression/anxiety and distress, and improved mood. A p-value of less than 0.05 is considered statistically significant. The analyses were performed with the R software environment.

3. Results

As reported above, 15 volunteers completed the MT program. The sample mean age was 53.40 years (SD = \pm 7.10 years). All the participants were patients with breast cancer with a mean time since diagnosis of 3.24 months (SD = \pm 3.08 months). Pie charts reported in Figure 2 depict the main socio-demographic characteristics of the sample. We observed a prevalence of married women (73.33%) with a college degree (66.67%). As concerns physical activity, almost half of the sample (46.67%) declared not to exercise regularly. Nearly the totality of the sample showed a positive or very positive attitude towards mountain hiking. Concerning the treatment followed at the time of the baseline, all but two

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received chemotherapy. For psychological support, almost half benefited from the service and only one required psycho-pharmaceutical treatment.

Figure 2. Descriptive statistics of the study sample.

As concerns the patients' quality of life, surveyed with the EORTC QLQ-C30 questionnaire, we can see in Table 2 that after the MT experiences the global health scale mean value as well as all the other mean values referred to the different function scales showed an improvement. At the same time, we observed a reduced range of values and variability of the measures in terms of coefficient

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of variation (CV = 330 SD/|Mx| – Global health T0 = 38.18% \rightarrow T1 = 21.56%, Physical function T0 = 23.37% \rightarrow T1 = 15.86%, Role function T0 = 42.78% \rightarrow T1 = 20.65%, Emotional function T0 = 35.21% \rightarrow T1 = 11.34%, Cognitive function T0 = 32.06% \rightarrow T1 = 13.60%, Social function T0 = 30.35% \rightarrow T1 = 19.50%). Regarding the symptom scales, we observed a decline in the related mean values and a reduced range of values but with a higher variability (Fatigue T0 = 49.04% \rightarrow T1 = 62.93%, Nausea T0 = 158.11% \rightarrow T1 = 263.90%, Pain. T0 = 81.26% \rightarrow T1 = 146.39%). Moreover, we calculated the QLQ-Total summary score (Giesinger et al. 2016), composed by taking the mean of all the scores of the EORTC QLQ-C30 except for Global health and financial difficulties. We observed an improvement in this latter score (higher is better functioning, fewer symptoms), with a declining variability (T0 = 18.10% \rightarrow T1 = 8.71%).

Table 2. Results of the EORTC QLQ-C30 questionnaire administration (n = 15).

	T0 (baseline)			T1 (follow-up)		
	Mx	SD	Range	Mx	SD	Range
Global health	53.33	±19.67	25 - 100	73.33	±15.28	33 - 100
Physical funct.	76.89	±17.36	47 - 100	81.33	±12.46	60 - 100
Role funct.	73.33	±30.31	0 - 100	85.56	±17.07	50 - 100
Emotional funct.	61.11	±20.79	25 - 100	83.33	± 9.13	67 - 100
Cognitive funct.	77.78	±24.09	33 - 100	91.11	±11.97	67 - 100
Social funct.	74.44	±21.83	33 - 100	86.67	±16.33	50 - 100
Fatigue	41.48	±19.65	0 - 78	27.41	±16.66	0 - 67
Nausea	6.67	±10.18	0 - 33	2.22	± 5.67	0 - 17
Pain	25.56	±20.06	0 - 67	16.67	±23.57	0 - 67
QLQ-Total	78.02	±14.12	47 - 100	88.68	±7.72	75 - 100

Mx: mean; SD: standard deviation

As concerns the patients' psychological distress, surveyed with the DT questionnaire, we observed before and after the MT intervention a low number of problems for each aspect but the emotional ones (Table 3). We observed a

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decline in the problem scale values and their ranges in the analysed sample but with a higher variability (Practical problems $T0 = 30.86\% \rightarrow T1 = 35.41\%$, Family problems $T0 = 39.17\% \rightarrow T1 = 57.48\%$, Emotional problems $T0 = 12.65\% \rightarrow T1 = 17.42\%$, Physical problems $T0 = 14.94\% \rightarrow T1 = 19.90\%$).

	T0 (baseline)			T1 (follow-up)		
Problems	Mx	SD	Range	Mx	SD	Range
Practical	20.00	±23.90	0 - 60	9.33	±12.80	0 - 40
Family	20.00	±30.34	0 - 100	8.89	±19.79	0 - 67
Emotional	48.89	±23.96	0 - 83	22.22	±15.00	0 - 50
Spiritual	6.67	±25.82	0 - 100	0.00	± 0.00	_
Physical	28.60	±16.55	0 - 52	16.63	±12.82	0 - 40
Stress level (DT)	7.13	± 0.64	6 - 8	1.87	± 1.30	0 - 4

Table 3. Results of the DT questionnaire administration (n = 15).

Mx: mean; SD: standard deviation

The overall stress level changed after the experience from 7.13 ± 0.64 to 1.87 ± 1.30 (Figure 3), suggesting a positive impact of the MT intervention.

As concerns the anxiety and depression states of the patients, surveyed with the HADS questionnaire, we observed initially a share of 46.67% for anxiety cases and a share of 13.33% for depression cases. After the MT intervention, both subscales showed a reduction to zero of critical cases, together with a decline in the mean value of normal cases (Table 4).

Even in the presence of a small sample of patients involved in the study, we performed a statistical test on the abovementioned key measures. A two-tailed paired t-test was performed to compare T0 and T1 scores, as only two time points were measured. Although the analysis of variance (ANOVA) results is reported for exploratory purposes, we acknowledge that a paired t-test is more appropriate for the current design. Assumptions of normality were tested using the Shapiro-Wilk test, which did not reject normality for the key variables (p > .05). In Table 5, we can see that the MT intervention produced a significant

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change in the observed values, especially for the DT level (p < .001) but also for the QLQ-Total level and the anxiety level (p < .01).



Figure 3. Changes in stress level before and after the MT intervention

Table 4. Results of the HADS questionnaire administration (n = 15).

	T0 (baseline)			T1 (follow-up)		
	%	Mx	SD	%	Mx	SD
Anxiety		9.93	±4.76		5.87	±2.39
normal (< 11)	53.33	6.00	±3.71	100	5.87	±2.39
elevated (≥ 11)	46.67	13.57	±3.51	0	0.00	± 0.00
Depression		7.67	±4.75		4.40	±2.80
normal (< 11)	86.67	5.71	± 2.70	100	4.40	± 2.80
elevated (≥ 11)	13.33	17.50	±2.12	0	0.00	±0.00

Mx: mean; SD: standard deviation

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	Mx _(T1 T0)	SD	SE		t	ę-value
QLQ-Total	10.66	±13.41	3.46	$\alpha = 0.05$	3.08	0.008**
DT	-5.27	± 1.49	0.38	$t_{\rm c} = 2.14$	13.70	0.000***
HADS-A	-4.07	± 5.18	1.34		3.04	0.009**
HADS-D	-3.27	± 5.59	1.44		2.26	0.040*
HADS-T	-7.30	±10.20	2.63		2.80	0.015*

Table 5. Comparison of baseline and follow-up measures.

Mx: mean; SD: standard deviation; SE: standard error; * $\rho < .05$, ** $\rho < .01$, *** $\rho < .001$.

We also performed an analysis of variance (ANOVA) for repeated measures on the scores mentioned above to evaluate the significance of the MT intervention on the patients involved in the study. Table 6 reports the results of the ANOVA test.

Table 6. ANOVA test results.

	$Mx_{(\Delta T)}$	SD	SE		F	ę-value
QLQ-Total	10.66	±13.41	3.46	$\alpha = 0.05$	329.35	0.000***
DT	-5.27	±1.49	0.38	$F_{c} = 3.34$	20.83	0.000***
HADS-A	-4.07	±5.18	1.34		5.21	0.012*
HADS-D	-3.27	±5.59	1.44		4.03	0.029*
HADS-T	-7.30	±10.20	2.63		10.64	0.000***

Mx: mean; SD: standard deviation; SE: standard error; * $\rho < .05$, ** $\rho < .01$, *** $\rho < .001$.

An ANOVA test for repeated QLQ-Total measures showed a significant difference between T0 and T1 (F = 329.35, p < .001). The mean QLQ-Total at T0 was 78.02, rising to a mean QLQ-Total of 88.68 at T1, for a difference of 10.66. A contrast in this difference was also significant (t = -3.08, p < .01). Concerning DT, the ANOVA test showed a significant difference between T0 and T1 (F = 20.83, p < .001). The mean DT at T0 was 7.13, dropping to a mean DT of 1.87 at T1, for a difference of -5.27. A contrast in this difference was also

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significant (t = 13.70, p < .001). Concerning HADS, the ANOVA test showed a significant difference for anxiety and depression subscales and for the overall measure between T0 and T1 (F = 5.21, p < .05, F = 4.03, p < .05, F = 10.64, p < .001, respectively).

4. Discussion

4.1 Comparison with related literature

Mountain Therapy (MT), as a nature-based intervention (NBI), has increasingly attracted scholarly interest in the context of oncological care, owing to its potential to support both physical and psychological health. Several recent studies have explored the specific benefits of immersive experiences in natural environments for individuals undergoing or recovering from cancer treatment. Gawrych and Slonka (2021) emphasised that therapeutic mountain hiking can be an effective modality for psychiatric rehabilitation, with natural settings contributing to emotional resilience and mental well-being. This is particularly relevant for oncology patients, who frequently experience elevated levels of anxiety and depression as a result of their diagnosis and treatment pathways.

Our findings align with this body of literature. Notably, the reduction in anxiety and depression scores observed in our sample (see Table 6) supports the view that MT may serve as a meaningful adjunctive tool in psycho-oncology. The improvement in psychological indicators observed in our study resonates with broader evidence that NBIs can provide a sense of psychological relief and promote emotional processing in individuals facing life-threatening illness (Park et al., 2022). From a physical health perspective, our results are consistent with existing studies demonstrating the role of physical activity in nature in improving patients' overall quality of life. Huber et al. (2023), in a randomised controlled trial comparing forest therapy with mountain hiking, found significant enhancements in both physical and psychological health among participants. These improvements are significant in oncology, where treatment regimens often result in fatigue and decreased physical function. Our data likewise show significant gains in the global health score and functional subscales of the EORTC QLQ-C30 questionnaire, indicating a similar trend. In addition to these psychological and functional outcomes, the physiological benefits of MT merit consideration. Exposure to high-altitude environments has been associated with cardiovascular adaptation and improved respiratory function - especially relevant outcomes for cancer patients with compromised physical endurance (Sydykov et al., 2021; De Pieri et al., 2021). Moreover, outdoor physical activities can help

mitigate Vitamin D deficiency, a common issue in oncology due to limited sunlight exposure during treatment. As Kárász et al. (2023) noted, restoring Vitamin D levels may be beneficial for overall health and potentially impact cancer prognosis. The combination of improved mood, reduced distress, and potential physiological benefits makes MT a promising holistic intervention.

Our study also contributes to theoretical frameworks such as the biophilia hypothesis (Wilson, 1984) and the stress reduction theory (Ulrich, 1981), which posit that natural environments possess restorative capacities that positively affect human health. The results support these theories' relevance in clinical contexts, reinforcing the value of incorporating environmental and psychological dimensions into cancer care. Furthermore, our findings are consistent with integrative oncology paradigms, which advocate for including complementary therapies – such as NBIs – alongside conventional medical treatments (Cassileth & Deng, 2004). By demonstrating measurable improvements in well-being, our study reinforces the notion that psychological and emotional support interventions are crucial in managing the overall disease burden in cancer patients. These outcomes also resonate with the concept of ecosystem services, particularly cultural ecosystem services, which include mental health enhancement and social connectedness as non-material benefits provided by interaction with nature (Millennium Ecosystem Assessment, 2005).

4.2 Study limitations and future research directions

While the findings of this pilot study are promising, several methodological limitations must be acknowledged. The most critical limitation concerns the small sample size (n = 15), which inherently limits the statistical power of the results and constrains the generalisability of the findings. Although the study was explicitly designed as a pilot, future research should involve a substantially larger cohort to increase robustness and allow for subgroup analyses. A target sample of 60–80 participants, divided into smaller sub-groups for the therapeutic sessions, may compromise statistical validity and preservation of individualised, supportive group dynamics.

A second major limitation is the absence of a control group. Without a comparator arm (e.g. standard care or an alternative non-nature-based intervention), it is not possible to isolate the effect of the MT intervention from other contributing factors such as time effects, placebo responses, or natural psychological recovery. The inclusion of a randomised controlled trial (RCT) design is therefore a crucial next step. Randomisation and blinding procedures would enhance the internal validity of the research and allow for more conclusive

causal inferences. The study also relied exclusively on self-reported psychometric measures, such as the HADS, NCCN Distress Thermometer, and EORTC QLQ-C30. While all instruments employed are widely validated, integrating objective physiological indicators – for instance, cortisol levels, heart rate variability, or immune markers such as T-lymphocytes and NK cells – would provide a more comprehensive and multi-dimensional assessment of the intervention's impact. This integration aligns with the broader movement in medical research to triangulate subjective and objective data for enhanced credibility.

Another limitation is the short-term nature of the intervention and assessment. The MT programme was conducted over four months (June to October 2021), and participants were evaluated only at baseline and immediately post-intervention. The absence of medium- or long-term follow-up prevents assessing sustained benefits or potential relapses. Given the chronic and often recurrent nature of cancer-related psychological distress, longitudinal studies with follow-up points at six months and one year would yield valuable insights into the durability of the observed improvements. Finally, the lack of physiological monitoring in the present study limits its capacity to capture the full scope of MT's potential effects. As indicated in the manuscript, these dimensions will be addressed in a more comprehensive protocol currently under review by the University of Calabria Ethics Committee. Future iterations of this research will aim to integrate a multidisciplinary assessment framework combining clinical, psychological, physiological, and environmental variables.

In sum, while this pilot study offers compelling preliminary evidence for the benefits of MT in post-treatment breast cancer patients, its limitations suggest that findings should be interpreted with caution. Nonetheless, the results provide a solid foundation for designing more rigorous, large-scale studies and reinforce the relevance of nature-based therapeutic interventions in contemporary oncology. Future studies will evaluate how the inclusion of biomarkers and longitudinal assessments can be balanced with ecological and logistical sustainability. The design will consider decentralised sample collection, minimal environmental impact, and efficient group management to ensure the preservation of the natural setting.

5. Conclusions

Cancer is the leading cause of death worldwide. Early diagnosis and treatment are crucial in reducing mortality. However, the relationship with natural

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environments plays a significant role in the overall well-being of individuals with severe illnesses. This has been highlighted in the scientific literature over the past decade and is supported by this pilot study conducted in an area of high naturalistic interest, such as the Sila National Park. Cultural Ecosystem Services, in particular, play a vital role in improving the quality of life by restoring capabilities, cognition, attention, mental health, and social cohesion. They also have a positive impact on clinical outcomes, as well as the immune system and cardiovascular function. Forest-care activities can be carried out in informal or unstructured ways in suitable areas and green facilities with qualified professionals. Ongoing scientific research and field experiments in Italy and worldwide seek to identify specific health intervention protocols as alternatives to traditional medical treatments. Limiting the study to breast cancer patients excludes other cancer types and stages. Including patients with different types of cancer or at different stages of treatment (e.g., pretreatment, during treatment, or long-term survivors) could reveal whether MT is beneficial across a broader spectrum of cancer experiences. Additionally, expanding the participant demographics (e.g., men and younger patients) would enhance the inclusivity and relevance of the research. The benefits of FT or MT may also be evaluated in terms of reducing personal and collective expenditures, such as the cost of treatments, medical consultations, pharmaceutical therapies, rehabilitation, and patient care facilities. Furthermore, greater care for biodiversity and improved accessibility and use of green spaces, including urban areas, help reduce the gap in caring for the most vulnerable individuals who are more exposed to an unequal environment. The study demonstrates significant relevance to the three overarching pillars of the United Nations Sustainable Development Goals (SDGs): social, economic, and environmental sustainability. First, the social implications of the study directly contribute to the aims of SDG 3, which seeks to ensure healthy lives and promote well-being for individuals of all ages. By addressing the psycho-physical rehabilitation of breast cancer patients, the research highlights the potential for nature-based interventions to improve quality of life significantly. The findings demonstrate that engaging with natural environments can reduce stress, anxiety, and depression while enhancing emotional resilience and social support among participants. This contributes to the broader objective of equitable and inclusive healthcare by promoting mental health as an integral component of overall well-being. Moreover, the study fosters community and collective support among participants, further embedding social cohesion into the therapeutic process. Such outcomes resonate with the commitment to health equity and the creation of inclusive care systems that address the holistic needs of vulnerable populations. Economically, the study

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aligns with SDG 8, which promotes sustained, inclusive, and sustainable economic growth alongside decent work for all. By demonstrating the therapeutic potential of cost-effective, nature-based interventions, the research suggests avenues for reducing healthcare expenditures associated with chronic and post-treatment conditions such as cancer. The use of accessible natural settings, rather than reliance on extensive pharmaceutical or high-cost medical interventions, introduces a sustainable healthcare model that has the potential to alleviate economic burdens on health-care systems and patients. This approach is particularly beneficial in resource-constrained settings, where innovative, lowcost interventions can substantially relieve public health infrastructures. Environmentally, the study underscores the importance of natural landscapes in advancing human health, aligning with SDG 15, which advocates conserving terrestrial ecosystems and preserving biodiversity. Conducted in the Sila National Park, a protected natural area recognised for its ecological value, the study exemplifies how responsibly managed natural environments serve dual roles as therapeutic spaces and conservation priorities. The research reinforces the concept of ecosystem services, particularly cultural and health-related benefits, by utilising the park's landscapes to foster physical and mental health improvements. Furthermore, it highlights the interconnectedness of environmental preservation and human well-being, suggesting that maintaining and expanding access to green spaces can be essential to public health strategies.

Future research should focus on several critical areas for enhancement to build upon the findings of this pilot study. As reported above, a larger and more diverse sample size will be employed to increase the robustness and generalisability of the results, allowing for the exploration of MT's effects across different patient groups and types of cancer. Moreover, introducing a randomised controlled trial design would address the current lack of a control group, ensuring that the effects observed are attributable specifically to MT. The promising results of the pilot study will be the basis of a most extended survey on the phenomenon. The next research phase could also benefit from the multidisciplinary approach used in our experimentation, involving experts from various fields to deepen the analysis of MT's physical and psychological effects. Finally, the possibility of expanding the study to different natural environments would help assess whether the observed benefits are specific to mountainous settings or extend to other types of nature-based interventions. These refinements will enhance the evidence base for the application of MT.

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The study was conducted following the Declaration of Helsinki. Ethical approval was obtained from the Annunziata Hospital Internal Committee, according to the Italian Law (Ministerial Circular n. 6/2002, published on G.U. n. 214, 12 September 2002), which specifies that observational studies need to be notified to the local ethics committee, which will then proceed either to a formal approval or to a simple acknowledgement of the ongoing study.

A letter of permission authorising the survey has been obtained from Annunziata Hospital. Informed consent was obtained from all participants for this study.

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Sustainable approach for socio-ecological development of urban areas

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Keywords: socio-ecological development; resilient and inclusive urban planning, sustainable urban development.



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Abstract. Resilient and inclusive city design has become essential for a sustainable future for urban areas in ecologically sensitive zones in the face of rapidly increasing urbanization and development. This paper explores the multifaceted dimensions of resilient and inclusive urban planning, focusing on its significance amidst urban expansion and socio-economic disparities affecting the corresponding ecologically sensitive areas. Drawing upon interdisciplinary literature and case studies, the paper examines the theoretical underpinnings and practical applications of resilience and inclusivity within urban planning frameworks. The ability of cities to endure and rebound from a variety of shocks and strains, such as natural disasters, the effects of climate change, and socioeconomic upheavals, is referred to as resilience. In contrast, inclusivity emphasizes the equitable distribution of resources, opportunities, and decision- making power among diverse urban populations, including marginalized groups and vulnerable communities. This study clarifies the relationship between resilience and inclusivity in the planning of urban areas by synthesizing theoretical discourse and actual evidence. It highlights the importance of integrating eco-sensitive approaches, adaptive strategies, and participatory mechanisms to foster resilience and inclusiveness in urban development processes. Furthermore, the paper underscores the role of governance structures, policy frameworks, and stakeholder engagement mechanisms in promoting resilient and inclusive urban environments. By critically examining the challenges, opportunities, and best practices associated with resilient and inclusive city planning, this paper contributes to advancing knowledge and informing policy discourse toward fostering sustainable and equitable urban development pathways.

1. Introduction

Urbanization is a widespread and irreversible global trend, whereby more than half of the world's population now lives in urban areas. The rapid expansion of cities poses significant challenges to environmental sustainability, particularly in

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regions with delicate ecosystems that are prone to degradation. Nonetheless, these challenges present opportunities for implementing sustainable urban development practices prioritizing resilience and inclusivity.

Cities depend on complex, interdependent social, ecological, and technological systems to function. People in urban areas rely on complex networks of institutional frameworks and technological infrastructure to access basic services like food, water, power, and healthcare. However, this approach frequently ignores the interdependence between the provision of urban resources and the ecosystems that sustain them. Disruptions can be extensively propagated through the interconnectedness of these systems, leading to unforeseen crises. Shocks may spread through transportation networks, chains of supply, and across various industries, including healthcare and finance, impacting local and global scales through nonlinear feedback mechanisms (Levin, 1999). These occurrences, coupled with issues of systemic racism and environmental justice, underscore the necessity for coordinated action across various scales and sectors. Additionally, urban areas are integrated into trade networks all around the world, impacting on resilience and sustainability at both local and global levels through decision-making processes at various scales (Chini, 2018; Krueger, 2020).

The urgency of these challenges is particularly pronounced in ecologically sensitive urban areas, which encompass diverse landscapes such as wetlands, forests, coastal regions, and biodiversity hotspots. While these areas hold substantial ecological value, they are also highly vulnerable to human-induced pressures. Achieving sustainable development in these contexts necessitates a balanced approach that preserves ecological integrity while meeting the needs of urban populations. This requires adhering to core principles of sustainable development, including maintaining environmental health, promoting social equity, ensuring economic viability, and safeguarding cultural heritage. Addressing these intertwined challenges and opportunities will be crucial in advancing resilient and inclusive urban development.

This paper analyzes sustainable development strategies in urban areas characterized by ecological sensitivity, emphasizing the interconnected nature of resilience and inclusivity in urban planning. Here the concept of resilience refers to the capacity of these urban systems—including their inhabitants, infrastructure, and institutions—to absorb, adapt, and transform in response to various shocks and stresses, while maintaining their essential functions and structures. This concept is integral to achieving urban sustainability, as it emphasizes the ability of cities to endure and thrive amidst environmental, social, and economic challenges. Whereas inclusivity refers to the deliberate integration

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of diverse populations—encompassing various socioeconomic, cultural, and demographic groups—into the planning, development, and governance processes of these urban environments.

This approach ensures equitable access to resources, opportunities, and decisionmaking, thereby fostering sustainable urban development that is socially just and environmentally conscious. Integrating inclusivity into resilience planning enhances the adaptive capacity of urban areas. When diverse community members are actively involved in decision-making, the resulting policies are more comprehensive and reflective of the population's needs, leading to more effective and sustainable resilience strategies. This participatory approach ensures that marginalized groups, who are often disproportionately affected by environmental challenges, have a voice in shaping interventions that directly impact their lives (Habitat UN, 2007). Moreover, inclusive urban planning promotes social cohesion and trust among community members, which are essential components of social resilience. Strong social networks facilitate collective action and resource sharing during times of crisis, enhancing the community's overall ability to withstand and recover from adverse events. In ecologically sensitive zones, where environmental risks may be heightened, fostering inclusivity ensures that all residents are prepared and can contribute to resilience-building efforts (Alsayed, 2024; Zhang et.al., 2024).

The research intends to fill critical gaps in urban sustainability literature by focusing on multi-scalar and multi-dimensional interactions between resilience and inclusivity. Additionally, it seeks to contribute to policy discourse and inform the development of inclusive and resilient urban governance systems. Thus, the following are the research questions:

- How do resilience and inclusivity interact within different potential frameworks to foster sustainable urban development in ecologically sensitive areas?
- What are the key governance mechanisms and participatory strategies that enhance resilience and inclusivity in urban planning?
- How can regional frameworks be applied to address localized sustainability challenges while maintaining global ecological balance?
- What role do top-down and bottom-up approaches play in achieving urban sustainability transitions, and how can they be effectively integrated?

To answer and to fill the above-mentioned questions and gaps, the study adopts a mixed-methods approach comprising an extensive literature review and case

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study analysis including different conceptual frameworks, empirical studies, government models, sectoral and interdisciplinary approaches.

2. Potential frameworks

2.1 A regional framework

The conceptual framework of planetary boundaries, as introduced by Rockstrom (2009a), has exerted a considerable influence on the discourse surrounding global sustainability at the international level. This framework delineates nine interconnected biophysical, or ecological, thresholds at the planetary scale (Figure 1a), which humanity should observe to avert "disastrous consequences." The introduction of planetary boundaries has spurred discussions within scientific and policy circles. Refinements to freshwater use (De Vries, Kros, 2013), nitrogen (Carpenter, 2011), and phosphorus (Rockstrom, 2009b) boundaries have been published recently, along with thoughts on a possible change in the global biosphere's status (Rockstrom & Karlberg, 2010). Additionally, there have been analyses of the governance implications (Biermann, 2012; Running, 2012; Sorace, 1993), recommendations for a unique method of defining land-related boundaries using net primary plant production (Barnosky, 2012) and critical assessments of the concept of the planetary boundaries. The expansion of the planetary boundary concept by Raworth (2012) and Nordhaus et al. (2012), incorporating social objectives into sustainability policy and practice, has resulted in the development of the 'Oxfam doughnut' framework, emphasizing the social justice prerequisites of sustainability (see Figure 1b). This framework facilitates the development of multi-metric 'compasses' to guide decision-making. The 'doughnut' framework uses the ideas of social foundation' and 'environmental ceiling' to symbolize respective social and ecological boundaries as it evaluates societal well-being levels and ecological process conditions within regional social-ecological systems at the regional scale. Planetary boundaries that are both socially and ecologically just can be used at several levels, including nation-states, national parks, watersheds, and subnational administrative divisions. The original paradigm for planetary boundaries acknowledges that crucial transitions can happen at any scale (Brook, 2013; Raworth, 2012; Scheffer, 2001). It also acknowledges that the consequences of surpassing several thresholds at regional scales might add up to global issues (Rockstrom, 2009a). However, long before these consequences become apparent on a global scale, the cumulative effects of environmental deterioration (Folke, 2004) can have a significant impact on the sustainability of

localized systems. This underscores the necessity for addressing both regional and planetary dimensions to ensure global sustainability. Therefore, concepts refined through the consideration of regional scales can iteratively inform the Planetary Boundaries refinement or redefinition. Substantial equality and governance considerations support the justification for taking regional-scale borders into account. Within the framework of planetary boundaries, protecting human welfare informs the scientific evaluation of restricting the use and deterioration of natural resources to avert major shifts in Earth system processes. Human welfare is contingent upon people having access to the natural resources required to meet their basic physiological needs, which include food, water, shelter, and sanitary conditions. Thus, planetary and regional borders should be placed in opposition to social foundations (Peters, 2011). The concept of planetary boundaries faces new transdisciplinary, intellectual, and ethical concerns when regional boundaries are addressed. These challenges arise from the need to explicitly address human drivers of change and social distributional issues. To ensure that resources are available and used to meet everyone's needs, many countries and areas face formidable and urgent challenges, highlighting the necessity of sustainable use of regional assets for the benefit of all people. Research indicates that the accompanying degradation of ecosystem processes may not be sustainable, even though agricultural expansion in developing nations is frequently seen as promoting fast economic growth and the reduction of poverty (Folke, 2011; Tilman, 2002). Analytical tools that map ecological processes at these scales are more likely to be relevant and useful for policy formation and resource governance, since natural resource management mostly takes place at regional levels as part of national and regional development planning.

It is imperative to challenge the constraints of dominant political-strategic timelines, which often give priority to short-term views and near-term actions. It would be in line with predictions of converging tendencies by mid-century if it were possible to recognize and abide by ecological boundaries across longer durations (Dearing, 2012a; Godfray, 2010). Communities living in areas already operating within risk thresholds may benefit from a new framework that considers several timescales and provides a prioritized list of restorative actions based on scientific evidence.

Depending on its goals, a regional boundaries framework can be created through a variety of methods. One method could be to compute the share of global resource consumption (like water) and effects on planetary boundaries (like CO2 emissions) that are specific to a certain region based on socioeconomic conditions (like in less developed countries). An alternative strategy may concentrate on the connections between regional resource management (like sustainable fish farming) and social well-being (like food security). Both strategies place a strong emphasis on equality concerns and call for social and ecological data integration.



Figure 1: Merging (a) Planetary boundary framework; (b) Social 'doughnut' framework (Raworth, 2012) into a new method for defining safe operating sustainable spaces (regional level). Source: Rockstrom et al., 2009 & Raworth, 2012

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2.1.1. <u>Interrelationships on spatial and temporal scales</u>. This framework emphasizes that resilience and inclusivity are inseparable in addressing regional sustainability. For example, while maintaining ecological boundaries ensures resilience by safeguarding critical ecosystem functions, inclusivity ensures that resources are distributed equitably, preventing social inequities.

Spatial: At a regional level, boundaries such as freshwater use or nutrient cycles can be managed more effectively by integrating localized ecological data with social metrics like food security or access to clean water (Barnosky et al., 2012; De Vries & Kros, 2013;). These boundaries reflect how cumulative regional actions impact global systems.

Temporal: Long-term adherence to ecological limits requires inclusive governance that prioritizes intergenerational equity and mitigates risks from developmental pressures in sensitive zones (Dearing et al., 2012a; Peters, 2011).

Thus, this regional framework reconciles ecological constraints with social justice imperatives, underscoring how inclusive policies reinforce resilience through equitable access and sustainable practices.

2.2 Social-Ecological-Technological Systems

Our subsequent framework is government-led, recognizing that effective coordination across intricate and interconnected urban systems necessitates appropriate forms of governance. Given projections indicating that nearly all future population growth will occur in urban areas, it is imperative to identify governance structures that facilitate inclusive decision-making, management, and planning, while enabling comprehensive system-wide transformations. This is crucial not only for the welfare of urban inhabitants but also for attaining climate objectives and preserving the biosphere (Dearing, 2012b). Despite the pressing need for governance mechanisms aimed at enhancing urban sustainability, there exists a lack of research on the intricacies of governing urban systems across various sectors and scales (Krumme, 2016).

Approaching the governance of urban sustainability transformations through a social-ecological-technological systems (SETS) perspective (McPhearson, 2016; Ostrom, 1990) underscores the complex and interconnected nature of urban systems, highlighting specific governance challenges and emphasizing the importance of identifying governance frameworks capable of coordinating across different sectors, spatial domains, and temporal dimensions. Figure 2. illustrates the concept of interdependent urban SETS and delineates the role of governance in shaping the evolution of such systems.

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The figure underscores three interacting elements of particular significance. (1) Equitable and dependable access to resources in Urban areas ('Provision of goods and services'), which form a crucial foundation for the livelihoods of Urban areas and facilitate inclusive political, economic, and social processes. (2) The interplay between bottom-up processes and economic activities with top-down initiatives by governmental actors ('Bottom-up and top-down processes'), wherein local experimentation and innovation can be encouraged by a balance between both forces, which can result in systemic changes. (3) The distribution of social influence, resource allocation, policy decisions, and urban SETS trajectories are all influenced by the power dynamics between the various actors. The arrows in (a) and (b) show how deeply ingrained governance is in these procedures.

2.2.1 Interrelationships on spatial and temporal scales. Resilience in urban systems depends on maintaining balance across these dimensions, while inclusivity ensures that diverse social actors actively participate in decision-making processes. SETS highlights governance as a critical element for managing system-wide transformations and fostering equitable development.

Spatial: At local and regional levels, SETS illustrates how urban governance must coordinate infrastructure (e.g., flood protection) with social well-being (e.g., housing equity) and ecological preservation (e.g., wetland restoration).

Temporal: The trajectory of urban systems depends on governance mechanisms that address immediate challenges (e.g., resource scarcity) while building resilience for future risks, such as climate change (Fischer et al., 2015; Ostrom, 1990).

Effective governance within SETS balances top-down policies with bottom-up initiatives, fostering adaptive capacities and inclusivity, essential for long-term urban sustainability in sensitive zones.

2.3 Multiple scales for urban Social-Ecological-Technological Systems

The ecosystem component within SETS encompasses the physical space or land that sustains urban economies and serves as the foundation for urban development. The social system is made up of different actors and how they interact, such as the government, private citizens, academics, corporate entities, and civil society organizations. These actors participate in decision-making processes related to ecosystem management, resource distribution and access, SETS spatial structure, and the use of goods and services produced from ecosystems. In addition to their technological and ecological surroundings, conventions, rules, cultural elements, and power dynamics all influence how actors interact with one another.



Figure 2. (a) Urban Social-Ecological-Technological Systems (SETS) involves intricate interdependencies among temporal & spatial dimensions. Shocks and stressors possess the capacity to influence individual or collective components of the SETS across various spatial scales, thereby shaping the trajectory of the urban system over time (denoted by the arrow indicating 'Temporal Dynamics'), (b) Embedded Governance refers to the intricate interplay between embedded actors and elements within Social-Ecological-Technological Systems (SETS), which collectively influence the governance of urban SETS. These actors navigate the interfaces among SETS elements, negotiating their interactions and coordinating processes of transformation aimed at sustainability across spatial and temporal scales. Source: Fischer et al., 2015.

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The technological system, represented by the physical infrastructure, encompasses networks, facilities, and buildings that facilitate the flow of resources, people, and information, represents the technological system. This infrastructure mediates interactions between ecosystems and social actors. For instance, flood protection infrastructure, designed and implemented by decisionmakers, serves to safeguard urban populations from natural hazards such as storm surges and riverine flooding. Another example is food supply chains, which involve ecological components like soils, water, plants, and animals, technological infrastructure for production, processing, and transportation, as well as social actors and consumers dependent on food delivery into urban areas. Effective governance of these systems necessitates inclusive design and planning processes, along with balanced and environmentally sustainable manufacturing and delivery of goods and services. In this context, governance shapes the overall evolution of SETS, influencing how communities coexist within their socialecological-technological environment. It determines decisions regarding flood protection measures, food production and distribution, and technological advancements.

Beyond official laws and regulations, governance includes informal and group action mechanisms such as information availability, efficient communication, rule enforcement, monitoring, and dispute resolution procedures (Clark, 2020; Ostrom, 2010), as well as incentives to encourage sustainable behavior, the establishment of supportive environments for community-based projects, the development of responsive functions, and collaborative production and management structures (Constantino, 2021; Frantzeskaki, 2019; Galuszka, 2019; Nyborg, 2016; Patel, 2017; Sparkman, 2021).

Efforts by governments and private actors to address sustainability challenges within SETS may encounter resistance, trade-offs, or unintended consequences across different system elements and scales (Bai, 2016). For instance, initiatives to reduce greenhouse gas emissions may lead to technological innovations throughout the supply chain but also raise concerns about resource exploitation and human rights abuses in distant locations (Riofrancos, 2019; Vandenbergh, 2018; Xu, 2020).

Incentives or programs which are only focused on a particular aspect of SETS may exacerbate imbalances across social, ecological, and technological dimensions of sustainability goals. Therefore, sustainability transformation efforts should consider all elements of SETS, recognizing their interconnections among various scales and sectors.

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2.3.1 <u>Interrelationships on spatial and temporal scales</u>: The urban SETS framework underscores that resilience is contingent on managing interactions among ecological processes, technological systems, and social dynamics across scales. Technological innovations, such as circular economy initiatives, promote resource efficiency, but their success depends on inclusive governance structures that ensure benefits are distributed equitably (Newell & Cousins, 2015).

Spatial: Managing urban water, energy, and food systems requires spatially integrated solutions that link urban centers with their resource catchment areas (Simpson & Jewitt, 2019).

Temporal: Urban transformations involve iterative processes where long-term planning aligns technological advancements with social inclusivity goals (Larsen, 2016; Markolf et al., 2018).

By fostering collaboration among diverse actors, SETS frameworks highlight how resilience and inclusivity converge to support urban sustainability transitions.

2.4 Managing resources and delivery of service provision in urban areas

Urban areas reside most of the Global population, exert significant pressure on natural resources, and contribute substantially to CO2 emissions and other environmental pollutants (Bai, 2018). Because of this, controlling the movements and demands of resources inside metropolitan areas is essential to maintaining both their own sustainability and the sustainability of the global ecological systems that provide them with goods and services. Resources are harvested, used, and then discarded into the environment as trash in traditional urban frameworks, which function in a linear manner (Van der Leer, 2018). Cities, for example, draw electricity from vast networks, extract metals and sand for construction and industry, import food from different parts of the world, and draw water from far-off groundwater reserves, lakes, and rivers. Nevertheless, the feedback mechanisms that are required to indicate the deterioration or the overexploitation of ecosystems between consumers and ecosystems are absent from these linear supply systems (Barthel, 2019; Floerke, 2018).

Conversely, cross-sectoral techniques place more emphasis on the connections across both inputs and outputs in various sectors (Liu, 2018). Reuse and recycling are two strategies that have been used to address scarcity issues. Both Singapore's NEWater recycling system and Namibia's Windhoek water delivery system distribute recycled water to consumers (Lahnsteiner, 2007; Lenouvel, 2014). Coordinated efforts can result in mutual advantages from coordinated systems

of water, energy, and food (WEF) management (Newell, 2020; Simpson, 2019). WEF nexus techniques combine the agricultural and wastewater industries by collecting nutrients for fertilizing crops and using treated wastewater for irrigation (Larsen, 2016). However, a great deal of coordination between ecosystems, technology, and social actors is needed for such cross-sectoral systems (Bai, 2016; Markolf, 2018). For instance, cooperation between wastewater management and water suppliers is necessary to guarantee the correct treatment and release of water, as well as to ensure its quality standards to prevent crop and soil contamination prevent soil. In the discourse on urban sustainability, ideas like the circular economy (CE), ecology of industry, urban metabolism, cradle-to-cradle, and life-cycle assessment are frequently discussed and offer alternatives to traditional linear systems (Newell, 2020; Newell & Cousins, 2015; Niero, 2017). Like the networked WEF nexus, CE techniques promote minimizing, recovering, reusing, and recycling resources and materials among all sectors (Obersteg, 2019). Furthermore, inclusion and well-being are emphasized as objectives in CE interpretations, highlighting the necessity of societal change to separate resource use from economic growth (Calisto Friant, 2020). Safe operating space models, for example, acknowledge the possibility for rising inequality and the disproportionate effect of climate change and environmental degradation on urban poor groups ((Bavel et al. 2021; Dearing, 2014; Krueger, 2020; Raworth, 2017; Ziervogel, 2019). They also combine ecological boundaries with social well-being.

Diverse social and political environments take distinct stances on sustainability issues. For example, circular city concepts have been adopted by China and Europe, though with different motivations and approaches to execution (Gravagnuolo, 2019). Although these approaches have different roots, some come from the social sciences and others from the natural/engineering sciences [66], there is a continuing convergence of CE principles among domains (Ben-David, 2021; Porkka, 2017). But there are still many real-world obstacles to overcome, like societal, technological, and legal impediments and the requirement for dietary shifts to plant-based diets. These call for well-thoughtout governance and policy measures (Boyer & Ramaswami, 2020; Marsh et al., 2021; Obersteg, 2019; Ranganathan, 2016; Weber, 2015). Accompanying the topdown incentive frameworks and laws, governance systems that place a high priority on inclusive policy-making procedures can help support bottom-up behavioral changes. Preventing externalities from problem-shifting and outsourcing requires a thorough grasp of sustainability goals that takes into consideration cross- scale and cross-sector connections (Chini, 2017; 2018).

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2.4.1 Interrelationships on spatial and temporal scales: Linear resource consumption in traditional urban systems often leads to ecological degradation and social inequalities. Circular economy approaches, which promote reuse, recycling, and resource recovery, offer an inclusive pathway toward urban resilience. For instance, Singapore's NEWater project ensures water security through advanced recycling, benefiting all residents equitably (Lahnsteiner, 2007).

Spatial: Cross-sectoral coordination ensures resource flows are managed holistically, benefiting both urban and rural areas that contribute to resource supply chains (Barthel et al., 2019).

Temporal: Sustainable resource management supports long-term resilience by mitigating resource depletion while addressing social inequities (Raworth, 2017).

This framework demonstrates that inclusivity in resource governance is crucial for maintaining urban resilience and ecosystem integrity.

2.5 Transformations in urban sustainability through top-down and bottom-up approaches

Different governance contexts show preferences for social or technical innovations, and they also determine whether these developments are imposed from above, originate from the ground up, or come from a combination of the two (Bauwens, 2020). Urban planning within Social-Ecological-Technological Systems (SETS) has a significant impact on socio-political processes, including the emergence of social movements, the inclusivity of urban development and local interest groups. It also affects CO2 emissions, public health outcomes, and the efficiency with which land and resources are utilized (Bassolas, 2019; Depietri, 2018; Sennett, 2018). Transformational forces can be aided or hindered by large-scale technology deployment and spatial planning in metropolitan environments, which are frequently typified by top-down approaches. Throughout history, physical spaces have played crucial roles as sites for public gatherings and expression of demands, as well as for the repression and segregation of social groups (Sennett, 2018).

Identifying supportive settings for local experimentation is a key theme in the research on urban sustainability transitions since it offers a way to get over entrenched systems and path- dependencies that support the current quo (Elmqvist, 2018). This strategy, known as "urban tinkering," highlights the importance of decentralized, bottom-up change and the participation of a variety of different social actors in the continuous SETS transformation process. This viewpoint is consistent with resilient systems in ecology, which benefit from

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redundancy, open exchange, diversity, modular organization, and other factors that increase their ability for adaptation (Carlisle & Gruby, 2019; Levin, 2019). Through the development of context-specific solutions, bottom-up efforts utilize the innovation and broad expertise of local players to nurture such traits. These programs and organizations create self-sufficient, modular structures that function best when they are moderately networked, allowing for coordination and communication (Carlisle & Gruby, 2019). Modularity, redundancy, and diversity strengthen buffering capacity, which reduces the propagation of shocks among modules and increases overall resilience (Levin, 1999; Nordbotten, 2108).

Different capacities are needed at different stages of urban change, such as the capacity to eliminate unsustainable practices and develop innovations that support resilience and sustainability and integrate these innovations into discourse, practices, and governance structures (Nordbotten, 2019). Furthermore, to guarantee that transformative processes continue to be flexible and in line with changing reflexive stakeholder action, social learning and sustainability goals, are essential (Castán Broto, 2019). Managing the complex dependencies of urban SETS, which need a synthesis of data across scales and sectors and are difficult for a single actor or entity to understand, requires social learning, especially collective learning (Johannessen, 2018).

Even among democratic regimes that appear to be comparable, there are significant differences in the capacities and enabling conditions for local administration at the urban scale. For example, in the 1980s, cities in the biggest democracies in the world, South Africa, Brazil, and India, experienced similar physical and social upheavals characterized by significant levels of inequality and divided citizenship. Divergent developmental outcomes, however, have been brought about by variations in the level of state-civil society embeddedness and the interactions among top-down and bottom-up processes. Brazil has strong, independent local capacity and participatory governance procedures, while South Africa is technocratic and centrally controlled and has good local government capacities (Heller, 2017). India is still mostly elite-dominated and has limited local governance capacities.

The actual conditions of urban governance frequently deviate from theoretical considerations of the prerequisites for urban development. Government initiatives are usually short-term and responsive rather than long-term and anticipatory; sectors are frequently handled by separated entities, disconnected across spatial scales and sectors; local sustainability initiatives are often fragmented, underfunded, and dependent on individual engagement, posing obstacles to lasting impacts and system-wide transformations (Hölscher, 2019).

2.5.1 <u>Interrelationships on spatial and temporal scales</u>: Urban transformations require the integration of top-down policies with bottom-up innovations. Top-down governance provides the regulatory framework for large-scale sustainability initiatives, while bottom-up approaches leverage local knowledge and community participation to address contextual challenges (Elmqvist et al., 2018).

Spatial: Local experimentation in urban neighborhoods (e.g., community gardens) complements broader municipal strategies, fostering system-wide resilience (Levin et al., 2019).

Temporal: Bottom-up initiatives encourage incremental, flexible changes that adapt to evolving social and environmental conditions, while top-down policies ensure alignment with long-term sustainability goals (Carlisle & Gruby, 2019).

Together, these approaches exemplify the interconnectedness of resilience and inclusivity, promoting equitable urban transformations.

2.6 Role of governance and power relations in urban SETS

Power dynamics and embeddedness play pivotal roles in determining the effectiveness of both bottom-up and top-down initiatives in transforming urban Social-Ecological-Technological Systems (SETS) (Borgström, 2019; Heller, 2017; Westman, 2019). This section concentrates on examining the interplay between governance embeddedness, power dynamics across sustainability and actors among actors of urban systems. Embeddedness, as discussed in scholarly literature, refers to the interdependence and relationships among societal actors and is closely linked with capacity and agency in governance processes (Heller, 2017; Kok, 2021). It provides the framework for organizing, resolving disputes, and tackling issues related to collective action. To ensure a participatory political process in urban contexts, it is imperative to consider the degree of embeddedness and the interconnection of actor connections among governance levels and sectors (Heller, 2017).

The idea of relational power is intimately related to the relational component of embeddedness (Kok, 2021). Relational power is generative, influencing, producing, and changing practices, social relationships, and institutional arrangements. It is braided into social- ecological-technological relations and embedded in social activities (Cooper, 1994; Kok, 2021). The integration of complex adaptive systems theory into the management of sustainability transitions emphasizes the need for a power relations concept based on SETS interactions as well as social agent interactions (Kok, 2021). Embeddedness is the term used to describe the connections between governance actors at different

levels and in different sectors, as well as how they interact with ecological and technical components of the metropolitan system.

Inclusive, multi-level, democratic and multi-scale characteristics are frequently found in the governance of sustainable urban transitions (Dahiya & Das, 2020). Embeddedness differs according on the context. A certain level of governance embeddedness is ensured both horizontally and vertically in Europe through local initiatives and authorities working with state, corporate, academic actors, and non-governmental, and organizations across different governance scales (Fratini, 2019). States have a big say in creating environmental regulations under the federal system of the United States; some of these policies can even be implemented and enforced locally. States with sizable marketplaces have the power to shape businesses and set norms across the country. For instance, California has taken the lead in establishing vehicle emissions regulations and in developing laws pertaining to plastic trash and air pollution (Rosner & Markowitz, 2019; Vogel, 2019). Due to insufficient cross-level integration between the central state, municipalities, and civil society, as well as an uneven distribution of power concentrated in the central state, urban areas in India frequently lack the potential for local self- governance (Heller, 2017; 2019).

Ensuring that local sustainability advancements do not jeopardize global sustainability can be achieved by integrating governance horizontally, spanning sectors, cities, and regions, as well as vertically, from the local level to the regional and global levels (Krueger, 2020; Hickmann, 2016). Over the past few decades, city networks have grown dramatically, encouraging cooperation between municipal governments around the world. Given the fact that choices made at the urban scale have an impact on many global processes, these networks have become crucial in forming and pushing global sustainability agendas (Acuto & Leffel, 2020; Mocca, 2017). In contrast to initiatives aiming at reaching a worldwide consensus among national entities, theoretical models imply that voluntary coalitions, such as these urban networks, may be more successful in solving the issue of climate change and other global ecological concerns (Hannam, 2017; Vasconcelos, 2020). These interconnected urban governance systems facilitate knowledge sharing and collaboratively pursue set goals to assist sustainability initiatives. Decentralized initiatives embedded within broader coalitions offer diverse responses to sustainability challenges, allowing successful approaches to diffuse to other locations. However, gaps between civil society initiatives and local governance bodies can hinder the spread of innovations across regions (Borgström, 2019).

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The vital responsibilities that social actors-both state and non-state-assume in governance processes are what make the urban sustainability ecosystem system SETS possible (Evans et al., 2017). In controlling uncertainty, maintaining the supremacy of law, redistributing wealth & resources, and coordinating policies, the state and other actors in regulatory or management roles are crucial (Evans et al., 2017). Civil society and Non-state actors must keep an eye on the state and hold it responsible through legislative and public actions, creating feedback loops between the state and civil society to prevent unbridled state power (Evans et al, 2017; Heller P., 2017). Loss of embeddedness between the state and society can lead to concentration of power at the national or state level, resulting in weak local governance despite significant economic growth (Heller, 2017; Meckling & Nahm, 2018). This can manifest in inequitable provision of public services, environmental degradation, and social inequalities. For instance, cities like Chennai in India face water scarcity and pollution issues, while cities like East Chicago and Flint in the US experience social inequalities exacerbated by out-ofbalance power relations (Krishnamurthy & Desouza, 2015; Sampson, 2017). Regulation by the state can support the preservation of social cohesiveness when sustainability changes. The reciprocal relationships between top-down and bottom-up processes, the balance of power within the governance system, and equitable urban service supply are illustrated by the urban governance cycle shown in Figure 2(b).

In addition to being crucial for preserving human well-being, critical infrastructure services help the state maintain law and order, encourage economic growth, and advance social inclusion (Centeno et al., 2017). On the other hand, efforts towards sustainability may be hampered by suspicion of the state and rejection of state power (Vandenbergh & Gilligan, 2018). It is a difficult task to rebuild inclusive government systems in environments where reciprocity and trust have been undermined. In these situations, government must strike a balance between the need for swift changes toward ecological sustainability and the gradual process of mending social ties, especially regarding excluded groups (Whyte, 2020). To summarize, the combination of power dynamics, governance framework, and embeddedness within SETS interactions can either facilitate or hinder sustainability transitions from local to global levels.

3. Discussion

The term "development" in the context of sustainable (urban) development, extends beyond the traditional focus on economic growth to encompass a

multidimensional approach that integrates environmental sustainability, social equity, and economic viability. This type of approach is necessary because economic growth has been critiqued for its potential to undermine the very principles of sustainability. Economic growth, in its traditional form, frequently leads to overexploitation of natural resources, ecological degradation, and exacerbation of social inequities. Whereas the concept of "economic viability," as referenced in this study, differs from mere growth in that it promotes an economic system capable of sustaining livelihoods while preserving environmental integrity and fostering social inclusiveness. This emphasizes that sustainable urban development needs to involve fostering resilience and inclusivity while addressing ecological sensitivity and socio-economic disparities. This approach contrasts with the conventional association of development with economic growth, which often overlooks the adverse environmental and social implications of unchecked urban expansion.

The increasing divergence between the functional realities of urban governance systems and the normative aspirations articulated in sustainability discourses highlights the need for a more methodical understanding of how urban governance can support the integration and modification of urban SETS. The body of existing literature has made a significant contribution to our understanding of the interactions between service delivery, top-down interventions, bottom-up efforts, sustainable resource management, and power dynamics among the factors influencing the changing pathways of urban SETS in various locations.

3.1 Regional framework.

Establishing a Regional Framework provides an aesthetically coherent method for comparing different regions, and it can also be used to evaluate how a region affects planetary borders. The SDGs, particularly in the "Post-2015 UN Development Agenda," have been critiqued for their broad scope and insufficient integration of localized contexts. While the SDGs provide a global framework for sustainability, their design and implementation have been criticized for several reasons like the lack of clarity in defining "development" often leads to conflicting priorities between economic growth and environmental sustainability; overemphasis on quantifiable targets; implementation challenges in ecologically sensitive areas and the SDGs often fail to address the systemic power imbalances that influence resource distribution and decision-making, limiting inclusivity and equity. These issues could be addressed and may benefit from the insights of the study like tailoring SDG implementation to regional

context and expanding the SDG indicators to include qualitative measures of resilience, inclusivity, and cultural preservation to provide a more comprehensive evaluation of sustainability, etc. Though there is strong evidence to support its implementation, especially in rural developing countries, there are a few warnings and ongoing difficulties that should be considered, for example the linear resource consumption model in many cities often contradicts the circular economy principles emphasized in SDG 12 (Responsible Consumption and Production). Similarly, systemic inequalities in resource access must be addressed to achieve the equity envisioned in SDG 10 (Reduced Inequalities). Addressing these challenges requires a shift from theoretical goals to actionable strategies that align with local realities.

3.2 Urban sustainability through ecosystem services

Within societal contexts, the utilization of technological tools by social actors to engage with ecosystems and manage resource extraction and allocation constitutes foundational elements for delivering essential services encompassing water, energy, food, health, and transportation. A substantial portion of scholarly discourse on sustainable service provisioning and resource governance adopts linear, circular, and nexus paradigms, predominantly targeting environmental or societal objectives. However, amalgamating these objectives necessitates mitigating pressures on natural ecosystems induced by climate change and global ecological degradation, alongside ensuring equitable access and fair resource distribution. Hence, sustainable service delivery surpasses mere material cycle management and ecological conservation, extending to addressing socioeconomic disparities and understanding cross-dimensional impacts on social, ecological, and technological systems. The intricate interplay of diverse resource fluxes within the urban metabolic framework, intertwined with stakeholder interests, renders delineating and attaining sustainability objectives a complex political endeavor within the governance framework of SETS.

3.3 Bottom-up and top-down approach

In the quest for effective sustainability transformations, engaging in experimentation processes spanning social, ecological, and technological domains is crucial. Notably, bottom-up approaches yield a spectrum of diverse, contextually adapted responses. Through embedded governance mechanisms, successful experimentation can propagate via dynamics of social learning. Consequently, grassroots initiatives and voluntary alliances play pivotal roles in overcoming entrenched patterns and disrupting dependency trajectories. Local

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endeavors can catalyze widespread behavioral shifts and normative framework alterations, disseminating across horizontally interconnected urban networks. Moreover, serving as modular components within polycentric governance frameworks, locally driven bottom-up initiatives, when interconnected across scales, provide systemic redundancies and resilience capacities essential for navigating flux periods and transformative change processes.

3.4 Governmental and hierarchical support

Governmental and hierarchical support is vital for fostering sufficient arenas for social dialogue and expanding promising local innovations conducive to sustainability transition. Governmental organizations must also create and implement regulations that minimize power imbalances between interested parties and guarantee the judicial, legislative, and executive branches' functional separation of powers. Widespread sustainability changes are mostly caused by the interaction of social processes, digital and physical surroundings, and grassroots initiatives and centralized control systems. Grassroots initiatives can drive sustainability transformations when embedded within a SETS governance framework and supported by infrastructures forged through multilevel engagements.

3.5 Power and urban governance

Urban SETS governance is characterized as multilayered, boundary-spanning, and multiscale frameworks, influenced by a heterogeneous array of actors. Power dynamics within this governance structure are susceptible to imbalance unless preemptively safeguarded. The authority wielded by cities in navigating internal shifts and external perturbations hinges upon power distribution and integration across various governance levels. Within urban settings, the inclusivity of decision-making processes, influenced by vertical integration and power dynamics, impacts levels of trust, consent, and societal well-being among residents. Evolution of SETS interactions, service delivery mechanisms, and social dynamics is contingent upon integrated governance across SETS components spanning local to global scales.

4. Conclusions

In conclusion, achieving sustainable development in urban areas while considering ecological sensitivity requires a comprehensive approach that recognizes the interdependence between resilience and inclusivity. By

incorporating risk-aware methodologies, adaptable strategies, and participatory approaches, urban centers can enhance their resilience to adverse events and societal pressures while promoting fair distribution of resources and opportunities. The design of governance systems, formulation of policy frameworks, and engagement of stakeholders play crucial roles in shaping resilient and inclusive urban environments. Moving forward, concerted efforts are essential to mainstream sustainability principles into urban planning and decision-making processes, ensuring the development of cities that are resilient, inclusive, and sustainable for present and future generations.

The frameworks presented in this study collectively illustrate that resilience and inclusivity are mutually reinforcing pillars of sustainable urban development. Across spatial and temporal scales, their interconnections shape governance, resource management, and urban transformations, ensuring that cities in ecologically sensitive zones can adapt to rapid urbanization while safeguarding social equity and ecological integrity.

A comprehensive and multifaceted viewpoint on the management of socioecological- technological systems enables a more profound comprehension of the intricacies entailed in tackling issues related to urban sustainability. By synthesizing insights from various academic disciplines, we underscore key principles conducive to fostering sustainable governance and transitioning from unsustainable to sustainable systems. The following is the main takeaway from the discussed literature:

- (1) The best way to formulate links and interactions hypotheses for further empirical validation and investigation is using the regional framework. An extensive collection of socio-ecological models, for instance, could be useful in locating critical points in ecosystem services and processes, which would help identify areas that are vulnerable to pressures during development. Furthermore, the framework offers a solid foundation for creating systems dynamics models that can identify feedback loops, enabling the investigation of ecological consequences linked to various social paths.
- (2) Achieving sustainable urban resource allocation and service delivery requires a holistic approach that extends beyond material flow management to incorporate social equity considerations, inclusivity, and the impacts of technological development, physical infrastructure, and urban planning into strategic planning and administration. While localized efforts targeting global sustainability concerns are underway, they must acknowledge and address the cross-dimensional impacts arising from global supply chains and resource distribution networks.

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- (3) Developing urban systems that are flexible and adaptive—capable of enduring shocks and disturbances while enabling revolutionary changes in the interplay between SETS—is crucial. The hierarchical interventions and governance frameworks that support regionally customized and diverse responses resulting from grassroots activities are essential to this endeavor. Urban settings and technologies are important mediators of these dynamics, functioning as interrelated elements of polycentric governing frameworks. Bottom-up approaches are effective in accelerating systemic reforms and scalable breakthroughs.
- (4) The integration of the urban governance framework across local, regional, and global dimensions is necessary for all aspects of the process, such as the equitable provision of basic services, the promotion of grassroots initiatives and creative practices, and the development of resilience to disruptions and changing urban dynamics. However, equitable allocation of power among stakeholders and the prevention of opportunistic conduct are necessary for this integration to be effective. Since numerous actors with different interests affect the long-term course of urban SETS, it is necessary to develop safeguards to monitor and correct power imbalances at all levels.

Additionally, for the successful implementation of the framework for sustainable urban development, which emphasizes resilience and inclusivity in ecologically sensitive areas, hinges on some facilitating factors like integrated governance structures, technological innovations, community participation etc. and impeding factors such as institutional fragmentation, socio-economic inequities, financial constraints, climate risks etc. that may either hinder or expedite its progress. Some of the above-mentioned impeding factors may lead to potential conflicts of interest between stakeholders with different priorities. For instance, developers and policymakers may prioritize economic growth, while environmentalists and local communities emphasize ecological preservation and social equity. Such conflicts could delay or derail the implementation of sustainability initiatives, particularly in areas where vested interests in resource exploitation conflict with conservation goals. Balancing these competing interests requires transparent dialogue, negotiation, and the establishment of shared objectives that align with long-term sustainability. To address the such and other multifaceted challenges of sustainable urban development, all the involved actors should hold a strong leadership & commitment, have access to robust institutions with adequate resources, ability to foster collective learning and should encourage bottom-up approaches.

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4.1 Contribution and future potential research

The main contribution of this study is the synthesis of interdisciplinary insights to provide a comprehensive framework for resilient and inclusive urban planning. It primarily includes 1) development of a multi-scalar and integrated approach to urban sustainability that links resilience and inclusivity, 2) providing actionable recommendations for policymakers and urban planners to enhance governance and participatory processes in urban systems, and 3) proposing strategies to balance ecological preservation with socio-economic development, particularly in regions where urban expansion threatens sensitive ecosystems.

The study's findings offer practical applications in urban policy formulation, governance, and resource management. For instance, the integration of SETS principles into urban planning can guide the design of resilient infrastructure and equitable service delivery. Furthermore, the study lays a foundation for future research to:

- Investigate the long-term impacts of governance models on urban resilience and inclusivity.
- Develop quantitative models to assess the effectiveness of urban sustainability interventions.
- Explore the role of digital technologies in enhancing participatory urban governance.

By addressing these areas, the study promotes the development of sustainable, resilient, and inclusive urban systems that can withstand environmental and social pressures while supporting equitable growth.

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The effect of tree harvesting rights on investment in tree growing and promotion of sustainable tree conservation practices by private land holders in Kenya

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Keywords: on farm trees; ecosystem services; right to cut; sustainable practices; policies; sustainable development.

Abstract. Trees and forests on private lands and farms play a crucial role in providing ecosystem goods and services that support human well-being. To promote sustainable management of these resources, many countries are assigning tree harvesting rights to private landowners. This strategy encourages tree-growing investments and sustainable practices. However, there is limited research on its effects in developing countries. This study focused on Kenya, using a case study approach and document content analysis to examine the impact of assigning tree harvesting rights on sustainable tree growing. Results show that since 1990, tree coverage on private farms in Kenya has increased by 48.12%, reaching 10,385,000 hectares by 2010. Farm forests are key to timber production, especially in Central Kenya, where up to 155 tree species are grown. These forests provide products like firewood and timber, but unsustainable practices such as low tree replacement and high tree densities pose challenges. Small-holder farmers are driven by high population density and market demand but face obstacles such as low tree prices and inadequate management techniques. Despite these challenges, farm forests have been essential, particularly during the Sawlog harvesting ban (2002-2012), and are expected to remain central to Kenya's forestry sector. While assigning tree-growing rights has had positive impacts, including ecological and economic benefits, it has also led to negative sustainability outcomes. Therefore, developing a stable legal framework, improving market access, and offering financial incentives are crucial for supporting sustainable forestry on private lands.

1. Introduction

Forests and trees on private lands play a crucial role in global ecosystems, contributing significantly to environmental sustainability, economic development, and social well-being (Sivakumar et al. 2024; Turner-Skoff & Cavender 2019). They provide essential services such as carbon sequestration, soil stabilization, and water regulation, while also offering valuable resources such as timber, fuelwood, and non-timber forest products (Turner-Skoff & Cavender 2019). In many developing countries, forests are vital for rural livelihoods, serving as a source of income, food, and energy for millions of people (Turner-Skoff & Cavender 2019). However, the management and conservation of these resources are often challenged by competing land uses, population pressure, and inadequate legal frameworks, which can lead to deforestation, land degradation, and loss of biodiversity (Gupta et al. 2024; Pandit et al. 2018).

In Kenya, trees and forests on private lands are important for human well-being and sustainable development (Mwenda et al. 2024). As such, a number of policies and legal instruments have been developed to promote the sustainable conservation and management of trees and forest resources. Internationally, the country has ratified a number of treaties, agreements and conventions aimed at promoting sustainable management of tree resources. Currently, the country's tree cover is approximately 12.13 % while forest cover is 8.83% of the total land area (Chisika & Yeom, 2024). Tree cover is projected to reach 30% by 2032 while forest cover is projected to reach 10% following a presidential directive that seeks to plant 15 billion trees on approximately 10.6 million hectares of degraded landscapes and ecosystems. To implement this directive, the government has adopted the "whole of society" and "whole of government" approach as allinclusive strategy for accelerating actions amongst various key actors. Increasingly, the role of private landholders in forest management is recognized as critical, particularly in the context of these trees growing and reforestation efforts. However, the effectiveness of these efforts is often contingent upon the legal and institutional frameworks governing tree harvesting rights. Despite the critical role that tree harvesting rights play in shaping landholder behavior and forest management outcomes, there is a notable lack of comprehensive studies examining this issue in the Kenyan context. Much of the existing research on forest management in Kenya has focused on public forests, community forest management, and land tenure issues, with relatively little attention given to the specific impact of tree harvesting rights on private landholders' investment decisions. Furthermore, while the importance of secure property rights for investment is well-established in economic theory, empirical studies that explore

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the application of this principle to tree harvesting rights, particularly in the context of smallholder and private landowners in Kenya, are limited. This research seeks to fill this gap by examining how the clarity, security, and enforceability of tree harvesting rights influence private landholders' decisions to invest in tree-growing activities in Kenya. By focusing on tree harvesting rights rather than broader land tenure issues, this study aims to provide a clearer understanding of the factors that drive or hinder investments in tree growing on private lands.

This study seeks to investigate the effect of tree harvesting rights on the investments made by private landholders in tree growing in Kenya. This research seeks to expand the understanding of the extent to which secure and well-defined tree harvesting rights incentivize landholders to invest in tree planting and sustainable forest management. The study will also explore how uncertainties or risks associated with tree harvesting rights may deter such investments and the potential implications for forest cover and environmental sustainability in Kenya. The study will draw on the theoretical frameworks of Property Rights Theory, Investment under Uncertainty Theory, Resource-Based Theory, and the Sustainable Livelihoods Framework to analyze the relationship between tree harvesting rights and investment behaviors. By doing so, it aims to provide evidence-based insights that can inform policy and legal reforms to enhance forest management and promote sustainable land use practices among private landholders in Kenya. This study contributes by analyzing the impact of tree harvesting rights on investments in tree growing, an under-researched area with significant implications for forest management. Kenya's diverse land tenure and policy commitments make it a crucial case for understanding and improving sustainable management practices for tree resources.

2. Tree harvesting rights, investments in tree growing and sustainable conservation practices

2.1 Theoretical background

Tree harvesting rights refer to the legal and customary entitlements that determine who can cut down, collect, and utilize trees and their products. These rights are crucial for managing forest and tree resources and promoting sustainable land use. The rights often include the authority to decide when and how trees are harvested, who benefits from the harvest, and how the proceeds are shared or reinvested. Tree harvesting rights can vary significantly based on local laws, land tenure systems, and customary practices. Secure and clearly
defined harvesting rights are essential for encouraging investment in tree growing, as they provide landholders with the confidence that they can reap the benefits of their labor. Conversely, unclear or insecure rights can lead to overexploitation or underinvestment, threatening both the economic viability of tree farming and the sustainability of tree resource management.

2.2 Empirical literature review

In 2020, global tree cover was 4.02 billion hectares, covering 30% of Earth's land, including natural, managed, and planted forests (World Resource Institute Website, 2024). Approximately 11% of forests are planted. Tree cover is concentrated in five countries—Russia, Brazil, Canada, the United States, and China—though countries like Equatorial Guinea, French Guiana, and Gabon have over 90% tree cover despite their smaller size. Tropical and subtropical forests account for 61% of global tree cover, boreal forests 24%, and temperate forests 15%. Since 2000, the world has lost 488 million hectares of tree cover, with losses increasing from 13.4 million hectares in 2001 to 28.3 million hectares in 2023. The tropics and subtropics lost 92 million hectares, while boreal forests lost 14 million hectares, though temperate forests gained 4.5 million hectares, possibly including old growth forest losses (World Resource Institute Website, 2024).

Trees outside forests (TOF), found in pastures, urban areas, and along roads, play a crucial role in agroforestry, enhancing productivity, soil quality, and biodiversity. They provide food, timber, and fuel, significantly supporting rural livelihoods. Urban trees improve air quality, reduce heat, and conserve energy. In Beijing, increased urban tree cover led to 81 new bird species (World Resource Institute Website, 2024). TOF also contributes over 75% of the 45.3 billion metric tons of carbon stored on agricultural land globally. However, TOF are often overlooked in conservation discussions. They cover 336 million hectares across the tropics but face challenges in mapping and definition due to diverse landscapes and inconsistent criteria (World Resource Institute Website, 2024; Hansen et al. 2013). Current forest loss data lack resolution for TOF changes, though projects such as the WRI Global Restoration Initiative are working to address this.

Wood products from trees on farms and private land have been vital to global economies for centuries, yet their supply faces increasing threats due to growing scarcity (Waswa et al., 2020). With global wood demand projected to triple from 500 million metric tons in 2018 to 1500 million metric tons by 2050 (Midgley et al., 2017), natural forests are declining (FAO, 2018), and plantation forests face

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land use and tenure challenges (Kanel et al., 2012). Global wood imports and exports have risen significantly since 2010, indicating an impending shortage (FAOSTAT, 2021). On-farm trees, which grow faster than forests, can help close the wood supply gap, improve livelihoods, and reduce deforestation (Zomer et al., 2014; Quandt et al., 2018). However, data on on-farm wood remains scarce and uncoordinated, impeding efforts to address forest governance and sustainability issues (UN-FAO, ITTO). The contribution of on-farm wood to global supply and its impact on tropical forest conservation is still unclear.

Mutune et al. (2024) highlighted the significant role of on-farm trees in wood supply as global industrial roundwood demand is projected to rise by 60% by 2030, reaching approximately 2400 mm³ (FAO, 2018). On-farm wood contributed 7.7-9.0% of the supply in China and 39% in India (Midgley et al., 2017). Despite growth in roundwood production and international trade, high deforestation and unregulated chainsaw logging, which accounts for 30-40% of timber production in tropical countries, threaten sustainability. The study underscores the need for better forest management and increased private landowner investments to address illegal logging and ensure wood supply.

A number of studies have examined the relationship between tree harvesting rights and investment in tree growing by private landholders. Dinh et al. (2023) noted that over the last three decades, Vietnam allocated over 14 million hectares in one of the largest natural resource decentralization programs in the developing world. Critics noted low household tree planting investments and questioned the impact of land institutions. Using nested logit and ordered probit models, the study assessed how perceptions of forestland tenure security influenced tree investment among 239 households in 11 Central Highlands communes. Results showed that concerns about potential land expropriation did not deter short-term acacia or long-term cashew investments. Factors such as labor availability, plantation costs, and market outlooks were significant, while short-term planting surprisingly reduced perceptions of tenure security. The study suggested that enhancing land tenure security and implementing investment-incentivizing policies could boost tree planting.

Lin et al. (2020) observed that in 2003, China introduced a new round of forest tenure reforms (CFTR) to encourage afforestation and boost rural livelihoods. This study analyzed the effects of land tenure security and logging rights on tree planting investments using long-term data from rural smallholders. By employing matching methods and Heckman models to address selection biases, the study found that complete logging rights significantly increased tree planting investments, while secure land tenure had an insignificant effect. Smallholders

confident of obtaining a harvest permit invested, on average, 52% more overall and 36% more in seedlings.

Xie et al. (2013) noted that since the early 1980s, China had implemented property rights reforms in collectively owned forests to encourage farmer participation in forest management. The study analyzed farmers' behaviors regarding labor and financial investments in forest management, using data from Tonggu County in southern China. Findings revealed that positive attitudes towards the reforms and higher income from forest products increased participation, while higher off-farm income reduced it. Farmers with more land and confidence in obtaining logging quotas managed forests more intensively. Conversely, households with older or more educated heads showed less interest in forest management investments.

Deuffic & Ni Dhubhain (2020) established that In Ireland, the consensus to expand forest cover had remained unchallenged for five decades. However, in 2014, private forest owners faced a catastrophic windstorm for the first time, leading to a qualitative survey of those affected. The disaster, beyond causing economic losses, undermined their belief in the benefits of afforestation programs. The study, using relational expectations theory, revealed that Storm Darwin altered their identity from pioneers to perceived failures. The reconstitution scheme provided guidance and reduced the risk of abandoning reforestation. Nonetheless, the storm made landowners more cautious about future afforestation programs.

Mejía et al. (2015) examined those smallholders controlled a significant portion of forestlands in the Ecuadorian Amazon, where timber, though not the primary income source, supplemented diverse livelihoods. Timber extraction was driven by a network of intermediaries connected to urban markets. Most small-scale operations were informal due to complex forestry regulations despite state efforts to simplify them. The benefits from timber extraction for smallholders depended on the organization of harvesting operations, the species harvested, and whether operations were conducted with formal permits. The study evaluated timber's role in smallholders' livelihoods, the impact of operational methods on benefits distribution, and the influence of urban markets on timber supply dynamics.

Kittredge and Thompson (2016) noted that non-industrial private forest ownership dominated the eastern USA, with most private owners valuing nonconsumptive benefits and showing minimal interest in timber revenue. A 25-year study of timber harvesting in Massachusetts examined the frequency and volume of harvests for five commercial species on private land, comparing these with

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quarterly stumpage prices. For four species, no relationship was found between stumpage prices and harvesting patterns. However, for one species, a consistent effect emerged: the volume harvested, and the number of harvest events were significantly related to stumpage prices west of the Connecticut River. This relationship was not observed in eastern Massachusetts and was inconsistent for other species. The study concluded that, under certain conditions, stumpage prices do influence private landowner harvesting decisions.

Bouriaud et al. (2013) proposed a property rights-based approach to analyze forest property rights in ten ECE countries, focusing on private forests, which total 7.3 million hectares and produce about 25 million cubic meters of timber annually. The study found that while forest management rights were retained by the State, timber withdrawal rights, though recognized in management plans, were economically restricted. Forest management planning was identified as a key top-down instrument with limited input from forest owners. This State-led approach affected the economic content of property rights and the adaptability of private forestry to challenges like climate change and industry demands. The study emphasized the need for detailed analysis of economic rights and the importance of understanding forest management planning to assess the evolution towards more participatory local governance.

Zhao et al. (2020) developed a statistical harvest choice model for Maine to understand how socio-economic factors influence timber supply. Using a multinomial logit model, it found that stumpage prices significantly impacted harvest decisions, though timber supply was inelastic to price changes (elasticities of 0.27–0.73). Simulations indicated that expanding conservation land could reduce total timber supply by 2%, but sawlog harvests might rise slightly. The model informs policies for sustainable timber flows, showing that conservation efforts do not substantially reduce timber harvests in Maine.

Ruseva et al. (2015) used a mail survey of Midwest U.S. private landowners analyzed tree planting behavior and policy effectiveness. Logistic regression showed cost-subsidizing policies, like free seedlings, significantly increased reforestation likelihood, especially for newer, college-educated owners with small recreational parcels. Key motivations included planning horizons, land connection, experience, and peer influence, highlighting the importance of economic incentives and capacity-building in promoting private forestation.

Schaaf & Broussard (2006) explored public perceptions of policy tools for private forests and their links to demographics and timber harvesting attitudes. A survey identified two policy categories: authority (regulations, sanctions) and

empowerment (learning, capacity-building). The public favored empowerment tools. Education predicted support for both categories, while attitudes favoring immediate timber harvesting negatively impacted support for private forest policies.

Rode et al. (2023) noted that native trees were vital for sustainable agriculture, offering economic benefits and protecting biodiversity. This study introduced a methodology to identify incentives for farmers to plant trees, propose financial packages, and integrate policies. Case studies from Uganda and Peru highlighted opportunities like technical support and income generation. However, challenges include weak institutions, limited funding, and low political priority.

However, there is also a growing tendency in many countries to progress towards developing private forest regulations as policy tools for guaranteeing tree harvesting rights and fostering a sustainable private forestry sector. United states of America, Germany, Finland and Sweden are leading in efforts to promote regulations for private forestry (Ellefson et al. 2007; Kotilainen Rytteri 2011; Hirsch & Schmithüsen 2010). The key components of private forest development regulations that confer tree harvesting rights and stimulate investment in tree growing include clear land tenure, incentives for sustainable practices, and flexible management plans. For example, in Finland, laws support private landowners with subsidies and tax benefits, encouraging sustainable timber production. Germany offers incentives for biodiversity conservation and forest restoration, while Sweden allows landowners to balance commercial forestry with environmental standards. These regulations ensure long-term profitability and environmental sustainability, encouraging private investment by providing security and financial incentives to landowners, fostering a stable environment for forestry enterprises (Ellefson et al. 2007; Kotilainen Rytteri 2011; Hirsch & Schmithüsen 2010). In countries without robust private forest development policy guidance, there is the growing tendency to impose tree harvesting bans which at times have dire negative consequences. The case study of Uganda outlined below exposes some of the impacts in the recent times.

2.3 Case study: Ban on tree harvesting for veneer exports in Uganda

In 2023, Uganda imposed a one-year moratorium on unprocessed timber exports, significantly impacting Mubende District, known for its private plantation forests (Infonile, 2024). The district had previously thrived with up to eight sawmills, mostly Chinese-owned, processing logs into veneer sheets for export to China. The government implemented the ban to curb unsustainable logging and address deforestation, fearing that Chinese timber consumption was

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exacerbating the problem. While the moratorium aimed to protect forest cover, it led to widespread job losses, reduced operations, and financial hardships, particularly for small-scale tree growers. Local farmers saw tree prices plummet, creating frustration and financial strain. Critics of the ban argued that the government failed to adequately consult stakeholders, leading to confusion over which timber products were affected. Although veneer exports were restricted, other low-value products like woodchips remained exportable, adding to market disruptions. The National Forestry Authority (NFA) defended the decision, citing data on deforestation in the Mubende area. However, local stakeholders questioned the ban's abrupt implementation and the government's regulatory capability. The situation highlighted tensions between environmental conservation and economic interests. Many stakeholders called for a more balanced, consultative approach to foster sustainable timber production without undermining livelihoods.

From the above review, on-farm trees owned by private landowners have a critical role in bridging the gap between rising global wood demand and dwindling natural forests. With global roundwood consumption projected to rise by 60% by 2030 (FAO, 2018), on-farm trees are increasingly vital in supplementing wood supply, contributing significantly to regions such as China and India (Mutune et al., 2024). Despite their potential, the sector faces challenges including deforestation and illegal logging, which threaten sustainability (Mutune et al., 2024). Addressing these issues requires better data on on-farm wood supply and investment in sustainable practices, which can enhance the role of on-farm trees in global wood markets (Waswa et al., 2020) and hence the need for this study. The existing literature shows that costsubsidizing policies, such as providing low-cost or free seedlings, significantly enhance tree planting investments, as seen in research from the Midwest U.S. and China. However, concerns about tenure security and market conditions can affect investment decisions, as demonstrated in Vietnam and China. Additionally, studies reveal that while policy tools such as empowerment and authority tools influence tree planting, their effectiveness is constrained by weak institutional support and limited funding, as noted in Uganda and Peru. From the case of Mubende District in Uganda the importance of clear, consultative policymaking is emphasized. Sudden government interventions, such as the moratorium on unprocessed timber exports, can disrupt livelihoods, lower tree value, and undermine long-term investments in sustainable forestry and tree growing. Moreover, the review has also identified gaps including the need for more comprehensive analyses of how varying legal and policy tools impact different tree species and management practices across diverse socio-economic contexts.

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Furthermore, there is a lack of understanding regarding the long-term impacts of forest management policies on economic and environmental outcomes, and the role of private landowners' participation in shaping effective policy interventions.

2.4 The context for tree harvesting rights and investment in tree growing by private landowners in Kenya

Kenya's total surface area is 59,196,877.24 ha which comprises of 97.8% land area and 2.2% water surface. Only 16% of the land is within medium to high rainfall areas, while 84% of the land is classified as Arid and Semi-Arid lands (ASALs) (KFS 2022). The Kenya's land cover classified into six categories: forest land, grassland, cropland, wetland, settlements and other Lands (KFS 2022). The National Land Cover Assessment conducted in 2021, established that grassland (including wooded grassland and open grassland (savannah)) is the dominant Kenya's land cover /land use constituting 70% of the national land area. (KFS 2022). Cropland is the second largest land cover / land use at 12%, followed by forestland at 8.83%, wetland at 3%, settlement at 0.32% and other land (Roads and other infrastructure) at 6% of the country's land area (KFS, 2022). The Restoration Opportunities Assessment study conducted by the MENR in 2016, also identified 38.8 million ha (65.5%) of Kenya's surface area as a potential area for restoration and tree growing, with Rangelands presenting the greatest restoration opportunities of 25.7 million ha (66.2%) of the national restoration opportunities. Croplands with a restoration potential of 7.6 million ha (19.6%) presents the second largest restoration opportunity; and Forestlands and Road reserves with restoration potential of 5.2 million ha (13.4%) and 0.3 million ha (0.8%), respectively. Rangelands, croplands and forestlands constitute 99.7% of restoration potential.

Trees and forests are vital to Kenya's economy and livelihoods, providing fuelwood for 82% of households, direct employment for over 750,000 people, and indirect benefits to over 4 million citizens. The forest sector contributes an estimated USD 365 million annually to the GDP, though this figure underestimates the sector's true value due to informal markets and subsistence use. The sector adds over KES 20 billion in value to various productive sectors, impacting on agriculture, energy, and tourism, which together contribute 33% to 39% of the GDP. Additionally, the ecological services of forests, such as those from the Mau Forest Complex and Mt. Elgon, are valued at over KES 339 billion annually, representing about 5% of Kenya's GDP. Non-Wood Forest Products (NWFPs) also provide significant economic and ecological benefits.

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Kenya's forest sector has undergone significant reforms to promote sustainable management, starting with the Forest Act 2005, later replaced by the Forest Conservation and Management Act 2016 and the 2010 Constitution. Key improvements include establishing the Kenya Forest Service (KFS), decentralizing governance through Forest Conservation Committees, and devolving forestry functions to county governments. The Participatory Forest Management approach led to the creation of 250 Community Forest Associations (CFAs) and 290 Charcoal Producer Associations (CPAs) for managing forests and regulating charcoal production. Additional reforms focused on forest research, private sector investments, and recognizing tenure for natural resources on community lands through the National Land and Land Use Policy.

However, Kenya's population, growing at 2.7% annually and expected to reach 66.3 million by 2030, poses both challenges and opportunities for sustainable tree resource management. A 2014 study by the GATSBY Charitable Fund estimated a national wood deficit of 12 million m³, projected to increase to 34.4 million m³ by 2030. The Ministry of Environment and Water Resources (MEWNR) the precursor of the current Ministry of Environment, Climate Change and Forestry projected a rise in the annual wood supply deficit from 10.3 million m³ in 2012 to 15 million m³ by 2032. Currently, trees on farmlands and communal forests supply over 90% of Kenya's annual wood needs. The other challenge and opportunity facing tree resources is that forestry in Kenya is a devolved function as per the Constitution, with county governments playing a crucial role in forest management and development. The 2016 Transition Implementation Plans (TIPs) for all 47 counties aimed to outline forestry responsibilities, but about 10 counties have not signed their TIPs, and many who did have not fully implemented them due to challenges in capacity and resource allocation. Despite this, 18 counties have established forestry departments. Empowering county governments with the necessary resources and capacity is essential for achieving the national target of 30% forest cover and fostering effective governance, economic development, and environmental conservation.

Cheboiwo (2016) noted that private forests and trees on farms were steadily increasing in area and species diversity. There are opportunities for public private partnerships in the sector. Equally, private landowners are recognized as important in the sustainable management of trees resources on their lands (Vellum website 2024). Kenya's 15 billion tree agenda is a key initiative in the nation's strategy to combat climate change by planting 15 billion trees over the next decade while involving private landowners. This effort aims to enhance

environmental resilience, counteract deforestation, and promote sustainability. The initiative's success depends on several factors: the careful selection of indigenous tree species to support biodiversity, strategic site selection for planting, and large-scale efforts to maximize impact. Crucially, community, including private landowners' involvement is essential, as it ensures trees are nurtured and protected, fostering a sense of ownership and responsibility (Vellum website 2024). Sustainable practices, such as agroforestry, and long-term management, including continuous monitoring and protection, are also vital. For success, comprehensive planning, adequate funding through public-private partnerships, strong policy support, and education campaigns are necessary (Vellum website 2024). These elements will ensure the initiative not only meets its tree-planting goals but also contributes to a broader strategy of sustainable land management and climate resilience (Vellum website 2024).

However, a recent turn of events surrounding the export of veneer sheets extracted from eucalyptus trees have caused a heated debate as to whether the government supports the growth of a vibrant private forestry sector or not. According to KNA Website (2024), the Kenyan government, through the Ministry of Environment, Climate Change, and Forestry, announced a suspension of raw veneer material exports with immediate effect. This directive, communicated by Cabinet Secretary, also instructed the Kenya Forest Service (KFS) not to issue any 'No Objection Letters' for such exports. It was noted that the suspension of exports was a firm measure aligned with the national environmental development goals espoused in the National Landscape and Ecosystem Restoration Strategy, which aims to restore 10.6 million hectares of degraded landscapes by planting 15 billion trees. The Cabinet Secretary emphasized that halting raw wood veneer exports was crucial to allowing trees to mature fully, thereby contributing to national restoration goals. In the ban notice, the government affirmed that it remained steadfast in its goal to achieve 30 percent tree cover, reinforcing its dedication to environmental conservation.

From this review, private landowners are critical in sustainable tree resource management, particularly within Kenya's ambitious 15 billion tree-planting initiative. However, if not properly evaluated, the current ban on veneer exports could jeopardize the private landowners' interest in private forestry and cause counterproductive consequences for the government's environmental restoration ambitions. Therefore, efforts should be made to investigate the impact of private landowners on sustainable management of tree resources could be enhanced through tree harvesting rights and hence the need for this study.

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3. Materials and Methods

3.1 Research design

This study employed a case study research design focusing on Kenya where private landholders engage in tree growing. The case study approach is wellsuited for exploring complex and context-specific phenomena, such as the effect of tree harvesting rights on investment decisions. The case study approach also supported the inclusion of qualitative data from diverse sources, offering insights crucial for developing sustainable tree management strategies. This ensured a holistic understanding of the multifaceted effects of tree growing rights, making it a robust and appropriate research design for this context.

3.2 Case study: Kenya

Kenya is in East Africa, bordered by Ethiopia to the north, Somalia to the east, Tanzania to the south, Uganda to the west, and South Sudan to the northwest. It has a diverse geography that includes the coastal plains along the Indian Ocean, the central highlands, and the Rift Valley, which stretches from the north to the south of the country. The highlands are home to the country's highest peaks, including Mount Kenya, the second-highest mountain in Africa.

Kenya's key socio-economic characteristics include a growing population of over 50 million people, with a significant proportion engaged in agriculture, which forms a crucial part of the economy. The country has a mixed economy with key sectors including agriculture, manufacturing, tourism, and services. Nairobi, the capital city, serves as an economic and financial hub for the region. Kenya's economic development is supported by its strategic location along major trade routes and its role as a regional transport and logistics center. Despite this, the country faces challenges such as poverty, income inequality, and environmental degradation, which impact its socio-economic landscape. Efforts are ongoing to address these issues through various development initiatives and policies.

3.3 Data collection

The study was qualitatively undertaken using a literature review and document content analysis to examine the effect of tree harvesting rights on investments in tree growing in Kenya. The study sought to examine the existing legal and institutional frameworks governing tree harvesting and how it affected tree investments. The literature review provided a comprehensive overview of the relevant theories and empirical studies on property rights, investment, and forest management, while the document content analysis focused on analyzing legal

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texts, policy documents, and institutional reports related to tree harvesting rights in Kenya. These methods allowed for a detailed examination of the legal and institutional factors that shape tree harvesting rights, as well as their impact on investment behaviors. By combining the case study approach with a thorough review of the literature and legal documents, this study sought to draw policy implications that can inform the development of more effective and equitable frameworks for promoting tree growing and sustainable forest management in Kenya.



Figure 1. Location map for Kenya

The literature review process in this study involved a systematic search and analysis of existing academic and grey literature on tree harvesting rights and their impact on investments in tree growing. Relevant sources were identified through databases such as JSTOR, Google Scholar, and institutional repositories. Key themes, including land tenure security, economic incentives, and sustainable forestry practices, were synthesized to provide a comprehensive understanding of the topic. The review also included critical evaluation of previous studies, identifying gaps and inconsistencies that informed the study's approach. This

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thorough literature review provided the foundation for the research framework and methodology. The document content analysis in this study was conducted through a systematic and structured process. First, relevant documents were selected, including policy papers, legal frameworks, government reports, and research articles that addressed tree harvesting rights and investments in tree growing. Selection criteria were based on relevance, credibility, and recency to ensure the inclusion of accurate and up-to-date information. Next, each document was thoroughly reviewed, focusing on key sections related to the study's objectives. The information was then coded into thematic categories, such as land tenure security, economic incentives, and environmental sustainability. These coded data were further analyzed to identify patterns, relationships, and emerging trends. The themes were synthesized to develop a comprehensive understanding of the issues. Finally, the findings were validated by cross-referencing with the literature review, ensuring consistency and reliability in the conclusions drawn from the document analysis. This methodical approach strengthened the study's overall rigor. The key documents review during document content analysis are shown in Table 1. All direct document references can be found in the reference list at the end of the manuscript.

3.4 Data analysis

The conceptual framework that examines the direct and indirect relationships between tree harvesting rights and investments in tree growing by private landholders in Kenya was used as the analytical tool in this study. From Figure 1, the direct relationship posits that clearly defined and secure tree harvesting rights directly encourage landholders to invest in tree-growing activities, such as planting and sustainable forestry practices. The framework highlights how tree harvesting rights impact tree-growing investments through mediating factors: perception of security, economic incentives, and environmental sustainability. Socio-economic status and geographical location further moderate these effects, emphasizing the role of income, education, and regional disparities. It provides insights into the dynamics of shaping sustainable forestry investments.

This analytical framework (Figure 2) was employed to examine the effect and relationship between harvesting rights and investments in tree growing by private landholders in Kenya. It guided the analysis by identifying key mediating factors, such as landholders' perception of security, economic incentives, and environmental considerations, which influenced their investment decisions. Data were analyzed to assess how secure tree harvesting rights directly encouraged tree-growing activities and how factors such as financial incentives, market

 Table 1. Key documents reviewed

Document	Type	Key information sought	Source
The Constitution of Kenya, 2010	Policy	Rights are guaranteed to citizens regarding a clean and healthy environment.	www.kenyalaw.org
The Wildlife Conservation and Management Act, 2013	Policy	Impact of the Act on Tree Harvesting Rights	www.kenyalaw.org
The Forest Conservation and Management Act, 2016	Policy	The legal requirements for tree harvesting and the institutions involved.	www.kenyalaw.org
The Environmental Management and Coordination Act (EMCA), 1999 (Amended in 2015)	Policy	The legal and institutional framework for environmental management.	www.kenyalaw.org
The Forest Policy, 2014	Policy	Guidelines for forest conservation, protection, and management	www.kenyalaw.org
The National Land Policy, 2009	Policy	Information on land tenure and how it affects investments in tree growing and sustainable harvesting practices	www.kenyalaw.org
The Agriculture (Farm Forestry) Rules, 2009	Policy	Information on a rule for maintaining a minimum of 10% tree cover on their farms and tree harvesting rights.	www.kenyalaw.org
The Land Act, 2012	Policy	Information on sustainable administration and management of land in Kenya	www.kenyalaw.org
Logging ban of 2019	Policy	Information on the effect of tree growth and investment	KIPPRA Website (2024)
Logging ban of 1999	Policy	Information on the effect of tree growth and investment	KIPPRA Website (2024)
Ban on export of raw wood veneers in 2024	Policy	Information on the effect of tree growth and investment	Nation Newspaper, 2024

access, and sustainability requirements mediated this relationship. The framework also accounted for socio-economic and geographical variations, providing insights into regional and demographic disparities in investment behavior. The results of this analysis were presented in two thematic areas,

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including, the current state of on-farm and private forestry in Kenya and effects of harvesting rights on tree growing investments and sustainable tree conservation practices as shown in the successive parts.



Figure 1. Conceptual framework for the effect of tree harvesting rights on investment in tree growing in Kenya

4. Results

4.1 The current state of on-farm and private forestry in Kenya

Results from reviewed literature show that since 1990, tree coverage on farms and private farms in Kenya has grown by 48.12% to 10,385,000 hectares by 2010, contrasting with a slight increase in private forests and a decline in public plantations. Farm forests are crucial for timber production, with Central Kenya's farms hosting up to 155 tree species and providing various products such as firewood and timber (Cheboiwo 2016). However, practices may be unsustainable due to minimal replacement of harvested trees and high tree densities that can compete with crops. Smallholder farmers are motivated by high population density and market demand but face challenges such as low tree prices, inadequate valuation techniques, and poor management practices. Solutions

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include improved infrastructure, extension services, and better valuation techniques. Despite these challenges, farm forests have been vital, especially during the sawlog harvesting ban from 2002 to 2012, and are expected to remain a key part of Kenya's forestry sector (Cheboiwo 2016).

Historically, tea estates, mainly owned by multinationals and local companies, dominated the sector by planting Eucalyptus for tea curing. Due to insufficient public forest plantations, investors including wood-based companies and largescale farmers have increasingly entered the forest sector. The growing demand for transmission poles, mainly sourced from Eucalyptus grandis, has further fueled this trend. Private sector investment in short rotation species and wood utilization has outpaced public plantations, driven by profit motives and advanced processing technologies. Despite marginal expansion of private sector plantations and high land prices limiting future growth, private sector forests are expected to thrive by leveraging efficiency and technology (Cheboiwo 2016).

Major players involved in private forestry in Kenya include the James Finlay tea estate, established in 1925 in Kenya's Rift Valley, spans 10,000 hectares, with 3,000 hectares dedicated to forests primarily of Eucalyptus species. It has improved its Eucalyptus grandis through rigorous breeding, developing 14 selections for both internal use and sale. The estate uses mechanized operations for planting and harvesting, achieving a high mean annual increment of 50 m³ per hectare and a sawmill with a 75% recovery rate. Timber from Finlay's operations supports tea processing and is sold locally, while surplus is utilized in infrastructure and packaging. The estate also supports Mau Forest Complex conservation and environmental education. Timsales Company Limited is another major wood-based industrial complex, which has been operational for nearly 70 years. It produces a range of wood products and relies on both public and its own plantations. It manages over 1,500 hectares of Eucalyptus grandis and supports forest development by collaborating with Kenya Forest Service (KFS). Homa Lime Company, founded in the 1920s, diversifies into forestry with 280 hectares of Eucalyptus plantations for firewood and 100 hectares preserved as a national monument. It is out-grower scheme partners with local farmers to cultivate Eucalyptus, ensuring a steady supply of wood and supporting regional tree growers (Cheboiwo 2016).

4.2 Effects of on-farm tree harvesting rights and promotion of sustainable tree growing practices

Private landowners in Kenya have the right to use, lease, sell, or develop their land within the confines of the law. These rights are guaranteed under the

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Constitution, 2010 and the Land Act, 2012. Landowners can also engage in agricultural, commercial, or residential activities, provided they comply with environmental and zoning regulations. Results from document content analysis in Table 1 also indicate that there are various legal and policy fronts being pursued in the country to promote tree harvesting rights and investments in tree growing as shown in Table 2. Even though the policy environment provides a strong framework for sustainable tree growing and conservation, it poses mixed implications for tree harvesting rights and investment. In particular, policies such as the Agriculture (Farm Forestry) Rules (2009) incentivize tree cover expansion but the veneer export ban of 2024 may burden landholders with compliance costs and denied access to the most needed markets for tree products.

Document	Does policy promote or hinder tree growing rights and	
Document	investments?	
The Constitution of Konva	Promotos tros growing through Article 60 which guarantees the right	
2010	to a clean and healthy environment including the systemable	
2010	to a clean and nearly environment, including the sustainable	
	management and use of on-farm tree resources.	
The Wildlife Conservation and	Promotes sustainable on-farm tree harvesting rights but seeks to	
Management Act, 2013	protect trees as wildlife habitats.	
The Forest Conservation and	Promotes sustainable tree harvesting rights and establishes Kenya	
Management Act, 2016	Forest Service to enforce those rights	
The Environmental	This act provides for the establishment of an appropriate legal and	
Management and Coordination	institutional framework for environmental management and tree	
Act (EMCA), 1999 (Amended	harvesting rights. It includes provisions that affect tree harvesting,	
in 2015)	particularly concerning environmental impact assessments (EIAs),	
,	which may be required before harvesting activities commence.	
The Forest Policy, 2014	Promotes on-farm tree harvesting rights, outlines forest conservation,	
	protection, and management guidelines, and emphasizes the	
	importance of involving local communities and private landholders in	
	sustainable forest management, including tree harvesting.	
The National Land Policy, 2009	Addresses land tenure issues in Kenya and grants property rights to	
	individuals, thus encouraging tree-growing investments	
The Agriculture (Farm Forestry)	Promotes sustainable tree harvesting by encouraging landowners to	
Rules, 2009	retain 10% tree cover on their farms.	
The Land Act, 2012	Promotes tree harvesting rights by promoting sustainable	
	administration and management of land in Kenya	
Logging ban of 2019	The ban targeted public and community forests. It served to promote	
	tree harvesting rights on private farms.	
Logging ban of 1999	Promote tree harvesting rights on private farms by banning tree	
	harvesting in targeted public forests.	
Ban on export of raw wood	Curtailed tree harvesting rights on private farms by withdrawing a	
veneers in 2024	market for tree owners.	

Table 2. Legal and policy environment for tree growing rights in Kenya

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Results from the reviewed literature on Kenya's context for on-farm tree growing and document content analysis of sources in Table 1 show that implementation of harvesting rights have various ecological, social, and economic effects on investments in tree-growing. Table 3 highlights the actual and potential effects of rights.

Type of effect	Positive effects	Negative effects
Ecological	 The incentive for increasing tree coverage and private farms (Cheboiwo 2016) Increased on-farm tree biodiversity (Cheboiwo 2016) Increased provision of ecosystem services such as firewood and timber (Cheboiwo 2016). 	 Disrupts the provision of ecosystem services Reduced biological diversity on farms Increased risk of deforestation. Increased risks of soil erosion and environmental degradation Increased risk of proliferation of invasive species Unsustainable management of tree resources (Cheboiwo 2016).
Social	 Increased household income and employment opportunities Increased revenue to fund development projects Increased decision-making power of communities in tree-growing initiatives Increased awareness and education about sustainable management practices 	 Conflicts between different interest groups, Increased social inequality. Health and safety risks where tree harvesting is unregulated
Economic	 Income generation for individuals and businesses Economic development in rural areas by funding infrastructure projects, public services, and local businesses Proliferation of efficient innovations and technologies for tree harvesting Increased export opportunities and revenue for economic growth Attract capital and investment. The James Finlay tea estate and other companies have significant investments in Kenya 	 It can lead to resource depletion. The timber market can fluctuate, leading to economic instability for those dependent on tree harvesting and related industries. It can lead to costly remediation and restoration efforts and reduced ecosystem services that have economic value. Disputes over tree harvesting rights and land use can lead to legal battles, increased security costs, and social unrest. Low tree prices when there is an oversupply in the market

Table 3. Effects of tree harvesting rights

In summary, the results show that the effect of tree harvesting rights on investment in tree growing and conservation practices in Kenya is mixed. Policies encourage sustainable tree management and increase investments through incentives such as land tenure security, farm forestry rules, and environmental protection. However, market barriers, such as the 2024 veneer export ban, limit investment potential by restricting access to key markets. The ecological, social,

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and economic impacts include positive effects such as income generation, increased tree coverage, and job creation, but also negative consequences such as resource depletion, deforestation risks, and conflicts, highlighting the need for balanced and effective policy implementation. These results are discussed in the successive parts.

5. Discussion

This study explored the often overlooked but essential aspect of forest management, focusing on tree harvesting rights and their influence on private landowners' investment in tree growing.

5.1 The role of private landowners in bridging the demand-supply gap for wood products

In Kenya, the analysis highlights key findings, emphasizing the vital role private landowners play in bridging the gap between increasing global wood demand and declining natural forest cover. With global markets increasingly seeking sustainable wood sources, Kenya's farm forestry sector, driven by private landowners, has become crucial to meeting these demands (Mutune et al. 2024; FAO 2018). Farm forests now contribute significantly to the production of timber, firewood, and other wood products (World Resource Institute Website, 2024; Midgley et al., 2017; FAO, 2018; Zomer et al., 2014; Quandt et al., 2018;). However, authors in this study believe that the success of these efforts is heavily dependent on the regulatory framework governing tree harvesting and the overall investment climate for private forestry (World Resource Institute Website, 2024).

5.2 Influence of regulatory framework on private investment in forestry

Several factors influence private landowners' willingness to invest in tree growing. Secure land tenure, government incentives, and a supportive regulatory environment are important for encouraging private forestry investment (Dinh et al. 2023; Lin et al. 2020; Xie et al. 2013; Bouriaud et al. 2013). In Kenya, legal structures such as the Forest Conservation and Management Act of 2016 and the Farm Forestry Rules of 2009 play critical roles in promoting tree harvesting rights and sustainable forestry practices on farmlands. The Act empowers private landowners to engage in tree planting and manage their resources sustainably, while Kenya's National Land Policy (Table 1&2) enhances land tenure security, a crucial factor in encouraging investments in on-farm tree growing. However, policy challenges, such as the logging bans and market disruptions, such as the veneer export ban, undermine tree-growing investment by private landowners by

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creating income instability for smallholder farmers. This finding underscores the need for a more balanced regulatory approach that encourages sustainable forestry while respecting landowners' economic interests.

Moreover, this study finds that multinational companies and large tea estates, such as the James Finlay tea estate and Timsales Company, are among the primary contributors to Kenya's private forestry (Cheboiwo 2016). These entities have heavily invested in fast-growing tree species, including Eucalyptus grandis to meet the market demand for timber and fuelwood. Their ability to make significant investments highlights the potential for large-scale private land owners and enterprises to adopt sustainable practices and respond to market demands. However, smallholder farmers face numerous challenges, including poor market valuation techniques and limited institutional support. These obstacles, along with a complex regulatory environment, hinder smallholders' full participation in the private forestry sector.

5.3 The effect of tree harvesting rights on tree growing investments

The study also reveals the threat posed by unsustainable practices, such as premature tree harvesting without adequate replanting (Table 3), which jeopardizes both the economic viability of tree growing and the ecosystem services provided by forests. These services include carbon sequestration, water regulation, and biodiversity conservation. This study observes that the failure to adopt sustainable management practices is exacerbated by weak institutional frameworks and ineffective enforcement of existing laws. While Kenya's forestry sector has the potential to contribute significantly to climate change mitigation and economic development, the absence of coherent strategies and support structures limits its overall impact. From these findings, the study emphasizes that secure tree harvesting rights are crucial to promoting private investment in forestry. Existing literature from Vietnam and China, demonstrate that secure tenure rights significantly encourage long-term investment in tree growing (Xie et al. 2013; Lin et al. 2020; Dinh et al. 2023). These countries have shown how legal clarity and government support can stimulate private engagement in forestry, a pattern that could be mirrored in Kenya. However, the study also underscores the need to balance economic growth with environmental sustainability. Regulations such as Kenya's Environmental Management and Coordination Act (EMCA) and the Wildlife Conservation and Management Act (Table 1&2) aim to protect ecosystems but can inadvertently create barriers for private landowners. These laws can restrict landowners' flexibility in managing their resources, making tree growing a less attractive venture. Furthermore,

sudden policy interventions, such as the timber export moratorium, disrupt market dynamics and leave landowners uncertain about the long-term viability of their investments. This is particularly relevant in the case of the veneer export ban, where smallholder farmers have expressed concerns about income loss and reduced market access (Table 3). In addition to regulatory issues, the study reveals that tree-growing investments are heavily influenced by market forces. Rising global demand for timber and wood products, coupled with increasing land values, has made private forestry a profitable venture for larger investors. However, smallholder farmers continue to struggle with low prices for their trees and poor management practices, which reduce profitability. To address these barriers, the study recommends improved market infrastructure, better valuation techniques, and enhanced government support, such as subsidies or other financial incentives. Without these measures, smallholders will find it difficult to compete in a market increasingly dominated by larger, well-resourced companies.

The findings of the study align with global trends in sustainable forestry, as seen in regions such as the Midwest U.S. and China (Lin et al. 2020; Kittredge and Thompson 2016; Ruseva et al. 2015). In these countries, government subsidies and incentives such as free seedlings have successfully encouraged increased treeplanting efforts by private landowners. Similarly, Kenya's Forest Policy of 2014 and the Agriculture (Farm Forestry) Rules (Table 1&2), which require farms to maintain at least 10% tree cover, have played a significant role in promoting private investment in tree growing. However, Kenya faces unique challenges that differentiate it from other regions. For instance, research from Uganda reveals the limitations of weak institutional support and inadequate funding in promoting sustainable forestry practices (Infonile website 2024). While Kenya benefits from institutions such as the Kenya Forest Service (KFS), corruption and bureaucratic inefficiencies still hinder private landowners' ability to fully participate in tree-planting initiatives (Table 1&2).

Moreover, this study highlights the impact of sudden government interventions, such as the 2024 veneer export ban in Kenya, which has sparked controversy. Similar situations in Uganda show how abrupt policy changes can lead to unintended consequences. In Kenya, the government claims farmers are harvesting immature trees, jeopardizing conservation targets (Table 3). However, private landowners argue for economic freedom, emphasizing the need for alternative markets (Table 3). They view their trees as private investments, and restrictions on market access, like those imposed by the ban, undermine their economic potential. Allowing market forces to determine prices would support both sustainable practices and farmer livelihoods. Whereas the authors agree with

the concerns raised by the private landowners in both Kenya and Uganda (Table 1; Table 2; Infonile website 2024; KNA Website 2024), there is also the need to examine this issue from the government's perspective, especially from the geopolitical perspective. One question can be asked, "why would China be interested in Africa's forest and tree resources when its forest cover is increasing? Is Kenya's veneer export prohibition the right move to make given membership to the World Trade Organization? From these questions, it is outrightly clear that China's appetite for Africa's wood resources is subject of international debate. What responsibility should China bear in replenishment of exploited private forest resources? Moreover, whereas players involved in the export ban debacle have valid justification of their demands, this study opines that indeed banning tree harvesting on private farms in Kenya could help conserve biodiversity, combat deforestation, and promote sustainable land use. However, a blanket ban may negatively impact farmers who rely on trees as a source of income, fuel, and construction materials (Table 2 &3). Instead of an outright ban, regulated harvesting with sustainable practices such as agroforestry and replanting programs could strike a balance between conservation and economic needs. Encouraging responsible tree management ensures environmental protection while allowing farmers to benefit from tree harvesting, supporting livelihoods without compromising long-term sustainability. Reviewed literature indicates that in most developed countries where there is a vibrant private forestry sector such as United states of America, Germany, Finland and Sweden efforts are focused on promote regulations for private forestry (Ellefson et al. 2007; Kotilainen Rytteri 2011; Hirsch & Schmithüsen 2010).

5.4 Market forces and investment challenges for smallholders

This paper also observes that the support for veneer exports to China stems from the economic opportunities it provides to eucalyptus tree farmers currently facing market saturation in Kenya. With local markets for eucalyptus poles operating below capacity, new investors in veneer sheets offer a solution by utilizing excess eucalyptus wood. The trend of exporting veneer to China is part of a global phenomenon, as seen in Vietnam, where it has become a thriving business. Rather than opposing exports, the focus should be on scientifically assessing the sector, understanding why semi-processed veneer is exported, and encouraging investment in local plywood manufacturing for both domestic and export markets. For farmers, selling veneer wood, even at lower prices, offers a salvage option as they shift back to more profitable agricultural ventures. The ban on veneer exports, if aimed at increasing eucalyptus tree planting, may

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backfire as farmers are already uprooting trees. These circumstances also highlight the importance of extension services in supporting private landholders.

5.5 The need for a comprehensive forestry policy framework.

In this paper, authors argue that forestry professionals through the Forestry Society of Kenya (FSK) have a significant role to play in this discussion by amplifying forestry extension methods in Kenya. Cost-effective and easy-toimplement forestry extension systems have proven successful in the country. For example, despite reduced funding under devolved governance, the Forestry Society of Kenya (FSK) could foster interest in private forestry and advocate for innovative mechanisms to promote forestry development, particularly in extension services. Successful models, which rely on dedicated forestry professionals, have demonstrated the viability of creating sustainable forestry networks. In these systems, skilled foresters lead while trained farmers, retired foresters, and teachers serve as frontline extension agents. One notable example is the Farm Forestry Field Schools (FFS) model, developed by the then Forest Department (FD) and now Kenya Forest Service (KFS), Kenya Forestry Research Institute (KEFRI), and the Japan International Cooperation Agency (JICA) between 2004 and 2009. The model trained over 200 forestry extension officers using a participatory approach, focusing on enterprise-based capacity development. Officers work with farmer groups on forestry enterprises like woodlots and tree nurseries. Trained facilitators continue providing services, reducing costs. With support, the system could boost farmer engagement and investment in forestry. Private forest development regulations in Kenya are essential for ensuring sustainable forest management and biodiversity conservation amidst increasing pressure on public forests. Private forests provide crucial ecological services, such as carbon sequestration and water regulation. Clear regulations would promote responsible practices, prevent illegal logging, and encourage investment. However, policy development faces challenges due to lack of funding and political support. Countries like the U.S. and Finland have successfully implemented private forest regulations, enhancing forest health and economic outcomes. These examples show how structured policies can balance environmental protection with economic benefits, offering valuable lessons for Kenya.

The implications of this study are broad, especially in terms of policy formulation and implementation. This study emphasizes the need for secure tree harvesting rights and a supportive legal framework to promote private investment in forestry. It suggests streamlining regulations, offering financial incentives, and

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refining policies to better support smallholder farmers, balancing economic and environmental goals to encourage sustainable forestry practices in Kenya.

6. Conclusion and policy implications

This study has highlighted the crucial role of tree harvesting rights in promoting private landowners' investment in tree growing and sustainable conservation practices in Kenya. The findings emphasize the importance of secure land tenure, supportive legal frameworks, and government incentives in encouraging private forestry. However, challenges such as regulatory barriers, sudden policy interventions such as the veneer export ban, and market disruptions have hindered investment in sustainable forestry, especially for smallholders. The study suggests that Kenya's regulatory approach should be refined to balance environmental goals, such as tree cover targets, with economic interests, ensuring that private landowners are incentivized to continue investing in tree planting. Additionally, market forces, including the growing global demand for wood products, should be leveraged to support both sustainable practices and farmers' livelihoods. Strengthening extension services and enhancing financial incentives for smallholders could address investment challenges and foster greater participation in forestry. Drawing lessons from successful models in other countries, the study calls for a comprehensive and consultative forestry policy framework that promotes responsible practices while respecting the rights of landowners. By aligning policy with market dynamics, Kenya can unlock the full potential of its private forestry sector, contributing to both environmental sustainability and economic development. The limitation of this study was relying on secondary data which may present some biases and inaccuracies, as the data may not fully reflect the current situation or capture all relevant variables. Consequently, the findings might not fully capture the realities of private landowners' experiences with tree harvesting rights. Future studies should consider incorporating other methods to provide a different perspective on the issue.

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Terror Management Theory and grandmetanarratives.

The search for a consilient ethics of conscious limitedness for the ecological transition

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- 1. Introduction: human beings as a cultural animal
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- Disembodiment, religion, and redeeming storytelling
 Religion, the myth of progress and the quest for re-embodiment
 Towards a consilient ethics of conscious limitedness
- 4. Conclusions

Keywords: sustainability; terror management theory; culture; spirituality.

Abstract. The multiple crises of the Anthropocene result from unsustainable individual behaviours and collective choices. Ethics play a key role in mediating human interactions with one another and the planet. To address these challenges, it's essential to examine dominant ethical systems and whether they can be redirected to encourage sustainable behaviours. However,



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the evolution of ethical systems remains unclear, making it difficult to identify leverage points for fostering an ecologically sound cultural paradigm. This paper draws on Terror Management Theory (TMT), which suggests that cultural systems evolve in response to humans' awareness of their biological limitations. We argue that both individual and collective actions rely on a shared system of beliefs, or grand-metanarratives, that give meaning to experiences. We highlight the disembodiment metanarrative in the Western Judeo-Christian paradigm as central to the expansion of global beliefs. This paradigm first promoted the religious myth of redemption, then legitimized the narrative of progress that underpins industrial civilization. We propose that a counter-hegemonic narrative is necessary, one that emphasizes the reembodiment of human existence within ecological limits. Pope Francis' Laudato Si' Encyclical Letter offers a potential stimulus for a paradigm shift towards a more empathetic, humble worldview. We argue that this shift must be ontologically open and epistemologically pluralist, laying the foundation for the emergence of global and localized ecological consciousness.

1. Introduction: human beings as a cultural animal

In the epoch of the Anthropocene, "the human relationship with nature has been absorbed by modern economic realities" whereby "modernity represents first the appearance of nature separate from culture, followed by the gradual withdrawal of social significance from the natural world" (Rogers, 1994, p. 20). As industrial civilization continues to unrelentingly and irreversibly push its way across planetary thresholds, threatening Earth's life-supporting systems, it becomes essential to ask whether the moral guidelines of the day are appropriate for and capable of facing the challenges presented by the Anthropocene. Andrew Hoffman, author of *How Culture Shapes the Climate Change Debate*, states that "we cannot recognize the environmental problems created by our way of life, nor can we develop solutions to address them, without first facing and changing the beliefs and values that have led to them" (Hoffman, 2015, p. 15).

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This article proposes an original interpretation of the process of sociocultural change that took place in Western countries over the past centuries and that originated the multiple crises of the Anthropocene. We argue that such a historical process unfolded around psychological motivations for human culture generally, and Western societies specifically. We explore how systems of knowledge grounded in grand-metanarratives, such as religion, helped the dominant belief system to evolve over time without compromising social cohesion. Finally, we discuss how metanarratives could eventually help to shape ecologically conscious belief systems by pursuing consilience between different forms of knowledge, including spirituality and religion.

The article is organized as follows: section two introduces and investigates the aspects of Western culture leading to the worldviews underpinning the Anthropocene. By adopting an existential psychodynamic framework grounded in Terror Management Theory, we explore how culture can be seen as "an adaptive function by a creative misrepresentation of reality to preserve psychological equanimity in response to the uniquely human awareness of death" (Solomon et al., 2003, p. 25). The third section of the paper identifies the "master-model" as the specific ethos of Western worldviews that emerged to offer people a solution to the existential paradox through a permanent quest for disembodiment, while simultaneously ensuring specific configurations of social reproduction and power relations. We explore how religious grandmetanarratives encompass these ethical premises as redeeming stories of salvation conveyed in the modern science's concept of progress. We therefore individuate in a consilient ethics of conscious limitedness the necessary element to imagine and enable the transition towards narratives capable of breaking the primacy of the "master-model" legacy.

2. Awareness of death and the Anthropocene

By imbuing reality with abstract, symbolic meanings, modernity can be characterized as a "quest to not only overcome and leave behind the constraints of living processes, but to ascend to a realm of reified abstractions from the perspective of which these constraints are invisible" (Gare, 2013, p. 328). This leads radical environmentalist and writer Dereck Jensen to proclaim that the culture of modernity's "problem lies above all in the belief that controlling and abusing the natural world is justifiable" (Jensen, 2006, p. 12).

In 1973, cultural anthropologist Ernest Becker published the Pulitzer Prizewinning book The Denial of Death which examined the critical role the

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awareness of death plays in the daily affairs of human life. Building upon the works of Otto Rank, Norman Brown, Carl Jung, Sigmund Freud, Søren Kierkegaard, and many others, Becker identified a juxtaposition that persists between the uniquely human awareness of death and our basic biological predisposition for survival. The advanced cognitive capacities of our ancestors, signified by the emergence of self-reflective consciousness, render human beings aware of the fact that we exist. To be alive, and to know that we are alive, brings about the unfortunate realization of our finite duration. What's more, death can occur at any moment, for reasons that cannot be controlled or anticipated.

Becker believed that this dreadful reality is a potentially paralyzing position for an animal to be in, but our ancestors overcame this predicament by constructing and maintaining cultural worldviews: humanly constructed beliefs about reality that are shared in groups to minimize anxiety by providing "ways for humans to believe they are significant enduring beings in a world of meaning" (Greenberg and Kosloff, 2008, p. 1882). By maintaining faith in a cultural worldview and meeting the cultural standards of value prescribed, humankind's existential predicament is mitigated by way of symbolic death transcendence, providing comfort in the fact that we are more "than mere animals fated only to obliteration upon death" (ibid).

2.1 Terror Management Theory: an empirical framework.

Although Becker's work was awarded the Pulitzer Prize in 1974, his writings were largely dismissed by academics as either untestable or wildly speculative (Solomon et al., 1998). But in the early 1980's, Terror Management Theory (TMT) was developed within the field of social psychology specifically to test Becker's hypotheses (Greenberg et al., 1986). By examining people's relationship with death in Western societies, TMT has identified three key findings: reminders of death provoke an exaggerated form of a belief or behaviour of cultural value; if a belief or value of cultural significance is threatened, death awareness is increased; and if beliefs or values of cultural significance are reinforced, existential anxiety is temporarily eliminated (Hayes et al., 2008). Furthermore, the provocation of negative thoughts such as dental pain, loss of limb, paralysis, or social exclusion could not consistently account for the empirical realities observed in TMT - nor could mood or physiological arousal, indicating the unique psychological influence death facilitates (for reviews see: Landau et al., 2004; Solomon et al., 1997; Burke et al., 2010). Examples in TMT research show that intimations of mortality have been found to: impel reckless driving

(Taubman-Ben-Ari et al., 1999); provoke support for extreme military interventions (Pyszczynski et al., 2006); influence greater optimism about the results of a national soccer team (Dechesne et al., 2000); increase preference for a charismatic political candidate (Cohen et al., 2004); increase food and drink consumption, particularly for those with low self-esteem (Mandel and Smeesters, 2008); and provoke derogation and even aggression towards worldview-threatening others (McGregor et al., 1998). Overall, TMT has found that "brief reminders of mortality have consistently led to efforts to bolster the psychological structures, cultural meaning, and self-esteem that are theorized to protect humans from existential mortality concerns" (Martens, 2004, p. 1525).

Confidence in one's worldview and its ability to protect the mind from anxiety highly depends on consensual validation from others. A broad social consensus is therefore essential in supporting a specific worldview. However, the "mere existence of divergent worldviews undermines this consensus, and therefore threatens faith in the absolute validity of one's worldview and reduces its anxietybuffering effectiveness" (Pyszczynski et al., 2006, p. 329). Admitting legitimacy of an alternative conception of reality necessarily undermines faith in one's own belief system, exposing oneself to the very anxiety these cultural meaning systems are constructed to mitigate. From a TMT perspective, "the ongoing ethnic strife pervading human history is in large part the result of humans' inability to tolerate those with different death-denying visions of reality" (Solomon et al., 2000, p. 201). This perspective aligns with social psychologist Leon Festinger's (1957) cognitive dissonance theory which emphasizes the importance of maintaining psychological consistency when encountering new information that may contradict personal values or beliefs. Cognitive dissonance is a "motivating state of affairs" where a person is compelled to change opinion, behaviour, or perception when encountering two inconsistent items of information in order to produce or restore consistency (Festinger, 1962). TMT's perspective on conflicting worldviews is also paralleled by the backfire effect, a phenomenon wherein "people counterargue preference-incongruent information and bolster their pre-existing views" (Nyhan and Reifler, 2010, p. 308) which may lead to "more attitudinally congruent information in mind than before the debate" (Lodge and Taber, 2000, p. 209). Confirmation bias is another term used in the psychology literature referring to the "seeking or interpreting of evidence in ways that are partial to existing beliefs, expectations, or a hypothesis in hand" (Nickerson, 1998, p. 175). Although the terminology may vary, the phenomenon remains: "people are motivated to maintain faith in and conform to cultural prescriptions of value because such views imbue the world with meaning, order, and stability and thus aid in the vital management of concerns about one's

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inevitable mortality" (Grabe et al., 2005, p. 33). Terror Management Theory offers a distinctively integrated account of social psychological phenomena including prejudice, altruism, conformity, terrorism, political and aesthetic preference, and interpersonal relations. The theory asserts that a wide range of behaviours can be better understood as "attempts to maintain meaning and value in the ultimate service of managing deeply held mortality concerns" (Landau et al., 2006, p. 131).

The TMT framework can also be extended to understand motivations behind economic behaviour among culturally distant societies. In exploring the relationship between money and existential fear, four studies found that death reminders amplified the value attributed to money, increased the appeal of and desire for money, and participants also experienced a reduced self-reported fear of death simply by having them count money in their hands (Zaleskiewicz et al., 2013). Money thus serves an explicit existential function, a finding that contributes to investigations of money's capacity to buffer feelings of social exclusion and physical pain primarily by offering a sense of power (Zhou et al., 2009). Brand connections were also found to function as an existential anxiety buffer, serving as a symbolic replacement for security, predictability, order, and even social connection (Rindfleisch et al., 2009; Fransen et al., 2008). Kasser and Sheldon (2000, p. 350) additionally observed that "death-based feelings of insecurity contributed to materialistic desires and behaviours" (See also: Christopher et al., 2006; Rindfleisch and Burroughs, 2004; Solomon et al., 2004).

2.2 Death denial in the Anthropocene

Much of TMT research has investigated the influence of existential anxiety on Western societal values and behaviours towards nature, animals, and the corporeal aspects of human existence. Empirical studies show that reminders of death were found to: decrease interest in physical sex while thoughts of physical sex increased death-thought accessibility (Goldenberg et al., 2002; Goldenberg, et al., 2000); cause people to unfavourably evaluate an essay describing humananimal similarity (Goldberg and Roberts, 2004); encourage the exploitation of natural resources such as forests for personal gain (Kasser and Sheldon, 2000); and lead to greater feelings of comfort from cultivated rather than natural settings (Koole and Van den Berg, 2004). Furthermore, reminders of human-animal similarity increased negative attitudes towards animals in the wake of thoughts of death (Beatson & Halloran, 2007), including pet owners who responded with less positive attitudes towards the average pet (Beatson et al., 2009). Death reminders

led people to disagree more with the idea that dolphins are smarter than humans, an idea that also led to increased death-thought accessibility (Soenke et al., 2018). The observed effects were not moderated by participants' gender, religious or political views, or pre-existing attitudes towards animal rights. Based on these empirical findings, TMT asserts that mortality concerns are extremely motivating in viewing oneself as distinct from animals, and that "people regulate the human body as a way to psychologically distance themselves from their animal nature and thereby deny mortality concerns" (Cox et al., 2007, p. 495; see also Goldenberg et al., 2000).

By complementing the psychological theories of motivation including confirmation bias, the backfire effect, and cognitive dissonance theory as aforementioned, TMT aids to better inform the critical purpose of cultural worldviews and the importance of maintaining faith in and conforming to the social standards of behaviour prescribed. Moreover, it becomes clear that these prescribed standards of value and behaviour advocate a particular code of morals which guide 'good' behaviour from 'bad', in line with the overarching worldview. However, how can the moral compass of individual minds guided by culturally imposed standards create habits which can quite rapidly become culturally ritualized and socially institutionalized? Loughnan et al. (2010, p. 156) highlight the morally troublesome behaviour associated with meat consumption in Australia as a specific case of cognitive dissonance "in which a belief and a practice are in conflict, creating an unpleasant emotional state that people are motivated to resolve". The apparent psychological conflict was termed the 'meatparadox' for the inconsistent beliefs in meat consumption: although many people enjoy eating meat, it also causes harm and suffering to animals. Bastian and Loughnan (2016) use the meat-paradox to explore the motivational nature of such psychological conflicts and methods for resolution. Through the process of dissonance reduction, Bastian and Loughnan (2016, p. 1) demonstrate how immoral actions are embedded within individual minds which can ultimately "spread morally questionable behaviour within local populations, shaping societies, institutions, and cultures in ways that ultimately protect people from experiencing associated discomfort" (ibid.).

One avenue identified by Bastian and Loughnan (2016) to resolve dissonance related to meat-eating involves perceiving animals as having a reduced capacity to suffer or understand which in turn decreases concern for their welfare. An entity is considered morally relevant by the extent to which it is considered to possess mental capacities (Waytz et al., 2010; Gray et al., 2011). Dissonance is therefore only experienced to the extent that an action causes harm or suffering

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to a morally relevant other. Loughnan et al. (2010) found that eating meat led participants to withdraw moral concern for animals and also led them to derogate the moral status and minds of the animals they specifically consumed. "In this sense eating meat appears to both narrow the breadth of moral consideration (fewer animals deserve it) and lessen the extent of moral concern (cows deserve less moral consideration)" (ibid, p. 158). Categorization is another process used to reduce perceived harm, a process that is extremely influential in a person's perception and experience of their social world (Rosch, 1999). Bratanova et al. (2011) present direct evidence for the role of categorization in meat-eating. Categorizing an animal as 'food' was found to reduce the animal's perceived capacity to suffer and subsequent moral standing, leading to the conclusion that "people may be able to love animals and love meat because animals categorized as food are seen as insensitive to pain and unworthy of moral consideration" (Bratanova et al., 2011, p. 193). Furthermore, Bastian et al., (2012) found that denying minds to animals alleviated negative emotions aroused by dissonance between concern for animal welfare and meat-eating behaviour.

Bastian and Loughnan (2016) suggest that the act of dissonance-reduction itself may encourage habit formation, where people begin to engage in repeated behaviour with minimal reflection which can reduce awareness of morally troublesome acts and quickly spread these morals among large populations. Martens et al., (2007) found, for example, that participants led to believe they had killed bugs in the past were more likely to kill more bugs. In order to justify past behaviour, people became more committed to killing bugs, suggesting that "further engagement in harmful behaviour served to reduce dissonance associated with past harmful behaviour" (Bastian and Loughnan, 2016, p. 6). This dissonance-based account of meat-eating provides integral insights into unethical behaviour in general, and prejudicial behaviour in particular by drawing on a number of parallels in the justification of prejudiced behaviour and the institutionalized forms of culturally embedded prejudice that have become naturalized and normalized. Haslam's (2006) review of animalistic and mechanistic dehumanization contributes to this parallel by demonstrating explicit methods used to deny uniquely human attributes to others and thus justify harmful attitudes and actions that impact a number of societal domains including racial stereotypes, sexism, people with disabilities, modern medical care practices, economic formalism, and attitudes towards immigrants.

Findings in TMT research demonstrate that mortality concerns can be managed not only by humanizing the self (Goldenberg et al., 2008; Goldenberg et al., 2006)
but humanizing the cultural group with which one identifies (Vaes et al., 2010). Mortality concerns are additionally managed by dehumanizing members of alternative worldviews (Goldenberg et al., 2009). By minimizing the moral standing of members of different cultures, the anxiety that arises from conflicting worldviews, and the dissonance that arises from harmful actions towards those others can be systematically eliminated, just as was the case for the moral standing of animals discussed above. The objectification of women, for example, provides "a relevant application of how existentially induced motivations to embolden one's uniquely human nature may induce an alternative kind of dehumanization that strips individuals of their human nature" (Goldenberg et al., 2009, p. 9). TMT offers an intriguing conceptual lens for understanding motivations behind infrahumanization, the "basic tendency for people to reserve more uniquely human characteristics for one's self and the groups with which one identifies" (Goldenberg et al., 2009, p. 9; See also: Leyens et al., 2000).

Dehumanization therefore supports the assertion that the ethics underlying the challenges of the Anthropocene, brought forth by Western modernity, can be understood as an ethics of domination, which is to say a blindingly forceful rejection of our own vulnerabilities as humans enabling us to take over control over human and extra-human natures¹. Acting as a form of disembodiment, the quest for dehumanization associated with the quest to dissolve the entire world into one global, bureaucratized and bureaucratically imposed market and subject the whole of humanity and all of life to the supposedly autonomous dynamics of technological progress is not only a denial of justice to people and nature and blindness to the conditions for the existence of civilization, but a denial of life itself (Gare, 2013).

The problems presented by the Anthropocene, amplified by the breach in the Earth's carrying capacity and planetary boundaries, are thus a direct result of Westernized modernity's mission to dehumanize, disembody, and therefore immortalize, itself. In pursuit of a symbolically abstract version of existence, modernity has allowed for the institutionalized justification of domination and dehumanization in order for the abusive relationship between industrial society and the natural environment to flourish. The following section explores how the

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¹ This observation is reiterated in Merchant's The Death of Nature in which she calls for the re-examination of "the formation of a world view and a science that, by reconceptualizing reality as a machine rather than a living organism, sanctioned the domination of both nature and women" (Merchant, 1980, p. XXI).

interpretation of the Anthropocene through Terror Management Theory (TMT), as outlined above, directly connects to the cultural and social significance of grand-metanarratives throughout the history of Western civilization. Specifically, we argue that the discursive frameworks of both religion and science have historically served as powerful tools for crafting meaningful narratives about a disembodied humanity, its fear of death, and its quest for redemption.

3. Disembodiment, religion, and redeeming storytelling

As noted by TMT theorists, "awareness of death is a unique force for humankind – one that changes the pursuit of meaning, value, and security in ways that profoundly affect the functioning of culture, ideology, and religion" (Pyszczynski and Kesebir, 2012, p. 76). In line with the empirical realities that TMT presents, Gare (2013) asserts that the mission of Westernized modernity, founded on liberal and free market ideologies, is to immortalize the human through an evermore dematerialized economy and society by way of 'disembodiment'. Disembodiment acts as a grand-metanarrative, or a project to separate communities from their own materialities (embodied forms). Dominant social classes produce and reproduce worldviews in which communities' aspirations, ambitions, and desires are liberated from their human and extra-human limits. This translates in a perpetual race to detach mass consumption from the (visible) materiality of production and its numerous forms of exploitation, including labor, energy, and nature.

The quest for disembodiment that characterizes modernism and postmodernism, it is argued, echoes in a more extreme form the delusions on which medieval civilization was based where the military aristocracy and the clergy, defining themselves through the ideal forms of Neo-Platonic Christianity, despised nature, the peasantry and in the case of the clergy, women. This argument is used to expose and reveal the oppressive and ecologically destructive drive underlying the aspirations of the dominant classes in the modern/postmodern world to disembodiment, whether this be seen as the quest to be unbounded by time and place, to be free of dependence on labour and natural resources, to be free of the humdrum of everyday life by entering 'virtual' worlds, or, as with post-humanists, to overcome the limits of the body by fusing with technology. These modern and postmodern forms of the quest for disembodiment, it is suggested, now threaten civilization, the future of humanity and most terrestrial life (Gare, 2013). Disembodiment has allowed money to "escape into infinite speculation" (Baudrillard, 1993, p. 7), legitimized the superiority of the ruling class, brought

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forth a mechanistic, reductionist scientific institution, and has reduced the common good to "nothing more than growth of GDP" and liberty as "nothing more than freedom to shop" (Gare, 2013, pp. 343-344). The narrative of disembodiment, of ultimate immortality, is an attempt to transform "the entire world into one giant economic machine, denying any significance to nature, or people, other than as a means to generate profits or as surplus to requirements and a law-and-order problem" (Gare, 2013, p. 342).

The dominant capitalistic economic system is quickly expanding its presence around the globe. Accompanied by a culture of consumerism, the materialistic lifestyle associated with capitalism is both highly addictive (Lea and Webley, 2006) and socially and psychologically corrosive (Christopher et al., 2006; Rindfleisch et al., 2009). The relationship between capitalistic values and psychological security entails that so long as the globalized market infrastructure focuses on materialistic tendencies, so too will the methods for coping with personal insecurities. This claim is fortified by Jackson (2013, p. 61) who, in discussing the link between ontological security and consumption, argues that "modern society has internalised a number of specific functions of world maintenance within the dynamics and organisation of consumerism". Furthermore, Jackson notes that although material goods have become "deeply implicated in the task of world maintenance", he finds that it is "precisely their continual failure truly to embody our ideals that makes them so successful as a strategy in the never-ending pursuit of 'displaced meaning'" (ibid.). Indeed, research investigating the institutions and ideologies of corporate capitalism show that "to the extent nations pursue de-regulated, free-market forms of capitalism, their citizens are more likely to endorse values that concern wealth, social standing and competition between individuals" (Hurst et al., 2013, pp. 257-258; See also: Kasser et al., 2007; Schwartz, 2007). Schwartz's (1992) circumflex model of values demonstrates the compatibility and conflicts between various values based on data collected across 80 nations. Values within the selfenhancement spectrum, such as achievement and power, are compatible with each other and adjacent within the model, but stand in relative conflict with selftranscendent values such as universalism and benevolence, which are situated opposite to values related to self-enhancement. These value orientations are directly correlated with different social and ecological attitudes and behaviours. For example, Hurst et al., (2013) showed that materialism is negatively correlated with both pro-environmental attitudes and behaviours. Engaging in selfenhancing values not only encourages the importance of environmentally damaging values, it also suppresses concerns for self-transcendent values associated with positive social and ecological attitudes. As demonstrated

experimentally by Maio et al. (2009), a change in one set of social values causes motivationally congruent values to increase in importance, while the importance of motivationally opposing values decreases. The mere activation of selfenhancement-oriented values such as social recognition, appearance, or financial success directly undermine social and ecological attitudes (Kasser and Ryan, 1996; Kasser and Ryan, 1993), a phenomenon that can be extrapolated from the individual to national level (Hurst et al., 2013). Of course, culture and values form the foundation of individual behaviour and the everyday dynamics of social reproduction, particularly in routine decisions such as purchasing goods, engaging with local communities, voting, and navigating other aspects of modern life. However, culture and values are not static - they are situated processes that emerge, whether implicitly or explicitly, from continually evolving historical and philosophical traditions embedded in grand-metanarratives. The following paragraph explores the diverse ways in which two major grand-metanarratives science and religion - have shaped Western cultures and their perspectives on the relationship between humans and the Earth.

3.1 Religion, the myth of progress and the quest for re-embodiment

Lynn T. White Jr. sparked the fervent debate about the role of the Judeo-Christian worldview in generating and fostering the West's escalating mastery in technology and the exploitation of nature in his article The Historical Roots of Our Ecologic Crisis (1967)². In his words:

"What we do about ecology depends on our ideas of the man-nature relationship. More science and more technology are not going to get us out of the present ecological crisis until we find a new religion or rethink our old one. Since the roots of our trouble are so largely religious, the remedy must also be essentially religious, whether we call it that or not" (White, 1967, p. 1207).

Also known as the "Lynn White thesis," it connected the ethos of Christianity and its central role in human life during the Middle Ages to the advent of the disembodied attitude towards the natural world. The influence of his "thesis"

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 $^{^2}$ He first gave a lecture in 1966 at the American Association for the Advancement of Science in Washington D.C. and then published this lecture in the journal Science in 1967.

was huge and enduring. White's ideas³, and the responses to them by other scholars, frame most of the contemporary discussion regarding the naturehuman dualism (Taylor, 2005). For White, medieval Christianity's progressive and unimpeachable support of technological advances, proven through medieval manuscripts and illustrations, and fuelled by the Book of Genesis story claiming a supposed supremacy of humans over nature, were decisive in the dislocation of Western anthropocentrism. Many biblical scholars vehemently argued that White misinterpreted the Genesis story and the genuine Christian spirit of stewardship. Even so, his hypothesis prevailed. However, what we found intriguing is that not much attention was given to his conclusion and recommendation, which, for us, were the most critical part of his argument for moving forward. The debate has focused around the hypothetical cause, and not around the possible recommended remedy. White concluded that, notwithstanding, religion is the answer to our environmental problems.

When confronting the ethical challenges of the Anthropocene, Schmidt et al. (2016) emphasize the importance of working with the world's axial religions (i.e. Christianity, Islam and Judaism) to find a common ground: "we cannot simply discard as inadequate all previous forms of cultural knowledge transmission" (ibid., p. 9). Following White's line of thought, Schmidt et al., also agree that ethics in the twenty-first century cannot rely exclusively or primarily on the scientific narrative, since it might reproduce colonial premises based on the Western, reductionist "master-model". They determined that there are in fact numerous reasonable ways of acquiring knowledge. Recognizing the richness of these alternative knowledges is critical for the comprehensive appreciation of ethics in the Anthropocene. Thus, religions (as collective forms of individual spiritualities) have invariably a central role to play.

The present socio-ecological crisis is the result of the splitting of two worldview stories—one based on a holistic, inclusive, comprehensive, realistic, embodied, factual and candid perception of reality, the other based on a reductionist, dualistic, fragmented, disembodied, dissembled, distorted notion of reality. Westerners decided to follow the second as the "master-model" (Schmidt et al., 2016) for progress, most prominently noticeable in the development of the different scientific disciplines and their methodologies. Between the eleventh and

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³ His ideas are also reinforced in his books Medieval Technology and Social Change (1962) and Medieval Technology and Religion: Collected Essays (1978).

the nineteenth centuries, Westerner dominant worldviews followed the ontologies of Niccolò Machiavelli, Francis Bacon, René Descartes, Galileo Galilei and Isaac Newton (Max-Neef, 2005a). Gare (2013) described these, under the scientific narrative, as dead interpretations of the world. A world where "[o]ut go sight, sound, taste, touch, and smell, and along with them have gone aesthetic and ethical sensibility, values, quality, soul, consciousness, spirit" (ibid., p. 338). The result is what Damasio (1994, p. 144) describes as humanity suffering from "a defect in the emotions that inform the deployment of logic" because emotions are "integral to the process of reasoning". Max-Neef (1991, p. 94) also describes this incompetence as lack of understanding:

Although we know how to describe and to explain, we seem to overlook the fact that describing plus explaining does not amount to understanding. The former has to do with knowledge, which is the stuff of science, while the latter has to do with meaning, the stuff of enlightenment. The result of this confusion is that at this stage of history, we know a lot but understand very little.

The result? A Western Judeo-Christian culture that "is profoundly and tragically allergic to any self-conscious metaphysics" and that has "embraced a decadent materialism that now is undercutting life's prospects" (Brown, 2015, p. 73). It is common knowledge that religion, as an integral part of one's cultural worldview, has provided civilization meaning and purpose for life. Even though there is limited research focused only on religion and TMT, in general, TMT has attributed a significant role to religion for its ability to relieve anxiety about the inescapable reality of mortality and the hope of self-transcendence (Batson & Stocks, 2004). Rowe (2016) wrote that in order to "transform capitalism we must transform the existential fear that feeds it". In other words, we will not be able to respond adequately to the present socio-ecological crisis if we don't help people to face their emotions of fear, denial and grief that comes with the overwhelming challenge of the crisis and the underpinning existential dilemma. This must be done in a sensible and, at the same time, empowering and fruitful way (Hathaway, 2016).

Another interesting insight is brought by Selinger (2004) who wrote about the "uneasy relationship between religion and development". According to Selinger, development theory -its study and application, supported by the social sciences-has disregarded religion and the spiritual spectrum. She argues that "development cannot exist without a spiritual dimension; that is, economic development will

not succeed if people are not spiritually developed" (ibid., p. 526). And despite the fact that social, political, economic and religious systems are closely intertwined to create societies and their cultures throughout history, "[b]y ensuring that religion is kept outside the social and economic spheres, the forces of market liberalism are able to prosper, as social capital and cultural support networks (dominantly rooted in religious communities) are kept at bay" (ibid., p. 540) for the continuous prosperity and economic power of the upper classes. This reinforces the total rupture of sacred and secular that is so prevalent in the political, scientific, economic and sociological domains. On the other hand, dealing with religion in the development arena is not without legitimate concern, as a result of the historical accounts of conflict and oppression from both sides. However, its avoidance is just as toxic, resulting in the dichotomized socioeconomic system we have been deluged by. Like gender and ethnicity, religion is an intrinsic part of people's identities and should be considered in development-related issues (Ver Beek, 2000; Selinger, 2004). The relationship between religion, the myth of progress, and the quest for re-embodiment is a rich and intricate tapestry that weaves together philosophical, spiritual, and cultural themes. The myth of progress represents a secular belief in humanity's continuous improvement through advancements in science, technology, and knowledge. Within this context, the quest for re-embodiment takes on a technological dimension. Moreover, concepts of digital immortality, where minds or consciousnesses are uploaded to digital mediums, offer a new frontier for the re-embodiment quest.

In sum, the quest for re-embodiment serves as a common thread linking both religious and secular perspectives. It embodies the fundamental human desire to transcend death and achieve continuity of self, whether through spiritual rebirth or technological re-creation. This convergence of religious and secular quests for re-embodiment highlights several important interconnections. Both provide avenues for hope and meaning, helping individuals confront the reality of mortality. Ultimately, the interplay between religion, the myth of progress, and the quest for re-embodiment underscores the diverse ways in which humans seek to understand and transcend their mortality. This complex relationship blends spiritual aspirations with technological ambitions, reflecting a universal human drive to navigate the mysteries of existence and strive for a continued presence beyond the confines of our physical bodies. The following paragraph presents several arguments to further unpack this complex set of ideas. We contend that redemptive storytelling plays a crucial role in the broader framework of the ecological transition. Moreover, we argue that within existing grandmetanarratives, new ethical foundations are beginning to emerge-ones that

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support a shift from disembodiment to re-embodiment—offering a potential pathway toward a more unified understanding of both the material and immaterial dimensions of human existence.

3.2. Towards a consilient ethics of conscious limitedness

This paper maintains that narratives and human culture are mutually coproductive. However, religion and the myth of progress are far more than mere "stories"; they function as ontological frameworks that shape the conditions for psychological valuation, social recognition, and, ultimately, human actioneither enabling or constraining these processes. Narratives are therefore means of knowing and understanding reality. As frames to conceive and assign particular meanings to reality, narratives can therefore become enormous sources of power, sufficient to assign political legitimacy to some voices, to ban and obscure counter-stories, and eventually to enforce complex strategies of social control (Benessia et al., 2016). What we called the grand "master-model" story has been incessantly sustained by the ruling classes through their interventions in educational organizations and other public institutions (Gare, 2013). In this way the disembodied, unemotional, positivist, and mechanistic content of the mastermodel story is perpetuated for the benefit of these elites. And the bedrock underneath might be related directly to Terror Management Theory (TMT). These are the "inauthentic sacred stories", as Korten (2015) describes them, which have favoured the Machiavelli, Bacon, Descartes, Galilei and Newton underpinnings (Max-Neef, 2005a), to serve the interests of these elites at the expense of the rest of the population. That is, "the myth of Genesis and Prometheus become one single equation" (Max-Neef, 1992, p. 40).

The ecological transition therefore requires an ethical transition as well. Pope Francis' Encyclical Letter, Laudato si' ("Praise be to you," Pope Francis, 2015) is a quantum jump in this direction, an attempt to change White's "thesis" and related discourses. Notwithstanding some sections in the Encyclical that still deserve further in-depth discussion about anthropocentrism,⁴ in general it is an

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⁴ For example, there are still traces of the anthropocentric dilemma in some sections of the Encyclical. An example is when it refers to the teachings of the Bible where "every man and woman is created out of love and made in God's image and likeness" (Chapter 2, section 65, pg. 47, The Wisdom of the Biblical Accounts). This is so even though the

appealing plea for ecological spirituality. Thirty-three percent of the world's population describe themselves as Christians, and in the United States alone this religious group represents 71% of the population--mostly Protestants (40%) and Catholics (21%).⁵ This data is important to understand the impact Laudato si' can have. Pope Francis contended what seems at this point obvious: that a better future lies outside scientific and technological progress, and that we urgently need a bold cultural revolution. Given the complexity of the ecological crisis, we need to realize that the solutions will not emerge from just one way of interpreting and transforming reality. Respect must also be shown for the various cultural riches of different peoples, their art and poetry, their interior life and spirituality. If we are truly concerned to develop an ecology capable of remedying the damage we have done, no branch of the sciences and no form of wisdom can be left out, and that includes religion and the language particular to it.

The Pope seems to answer E.O. Wilson's (2006, 1999) well known request for consilience among the different disciplines. Furthermore, he broadens consilience to include all types of cultural knowledges and openly invites science and religion to enter into a productive dialogue to achieve a common ground from their distinctive but essential approaches to understanding reality. In the words of E.O. Wilson (2006, p. 5):

"If religion and science could be united on the common ground of biological conservation, the problem would soon be solved. If there is any moral precept shared by people of all beliefs, it is that we owe ourselves and future generations a beautiful, rich, and healthful environment".

Wilson (1999) emphasized the need to achieve wisdom, and this entails an educational system that can help humanity synthesize -what the ecological economist Max-Neef (1991, p. 94) describes as understanding the "stuff of enlightenment". In other words, see reality as it is, grasp the larger picture. As the scientist Wilson proclaimed (1999, p. 294)), "[w]e are drowning in information, while starving for wisdom". Likewise, the theologian Pope Francis urgently pleads for "a humanism capable of bringing together the different fields

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Encyclical condemns anthropocentrism, as the "Promethean vision of mastery over the world" in Chapter 3, section 115, p. 86, The Crisis and Effects of Modern Anthropocentrism. ⁵ Data from Adherent.com: National & World Religion Statistics – Church Statistics – World Religions: Retrieved on October 10, 2016: <u>http://www.adherents.com/</u>. Also, from Pew Research Center: Religion and Public Life. Retrieved on the same day from: <u>http://www.pewforum.org/religious-landscape-study/</u>

of knowledge, including economics, in the service of a more integral and integrating vision", because "specialization which belongs to technology makes it difficult to see the larger picture. The fragmentation of knowledge proves helpful for concrete applications, and yet it often leads to a loss of appreciation for the whole, for the relationships between things, and for the broader horizon (...)" (Pope Francis, 2015).

In the book The Tao of Liberation, Hathaway and Boff (2012) describe how the story of the universe, as revealed by science, could be a narrative conveying a "process of revelation that can guide and orient our lives" (ibid., p. 197). It is fascinating to witness how science, religion, and spirituality,⁶ after centuries of bifurcation, are again finding a common ground. We are awakening to the fact that science "without a soul" is a misfortune and, on the other hand, a solely spiritual approach in a complex world is not feasible (Capra and Luisi, 2014). Buddhist humanistic philosophy can teach us to deal with the material and sensual worlds and satisfy basic human needs in harmony with the environment. This fundamentally departs from the individualistic, self-interested, utilitarian and detached maximiser of worldly gain, Homo economicus (Daniels, 2005; Timmerman, 1988). Even the late and renowned economist E.F. Schumacher (1973) was able to incorporate Buddhist's worldview using the "Right Livelihood" as the core goal for economics: earning a living in a way that does not cause harm, and that follows the ideals of love and compassion. The concept

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⁶ We think it is important, at least in a footnote, to differentiate spirituality from religion. The word "spirituality" comes from the Latin word spiritus, which means "breath", from the breath of life. It is a broad, inclusive concept, encompassing a wide range of perspectives. In general, it includes a sense of connection to something bigger than ourselves, and it involves a search for meaning in life. It is a universal cultural experience - often described as "something that touches us all": mystical, sacred or transcendent moments; a deep sense of aliveness and interconnectedness with the whole, the cosmos, the "something" that is greater; the sensation of oneness or absolute unity; also, the fascination with the mystery or the miracle of existence. On the other hand, religion is the organized aim to understand and interpret the spiritual experience through a system of doctrine, practices and worship by a group or a community of people that follow the teachings of a spiritual leader. It comes from the Latin word *religare*, which means "to bind" and *religio* which means obligation, bond, reverence. Yet, religion and spirituality, while not homologous, are intimately intertwined. Spirituality can exist outside conventional religious practices, but it is almost impossible to ponder spirituality without contemplating religion (Capra and Luisi, 2014; Hathaway and Boff, 2012; Boyd, 2012).

was further developed by another economist from the Global South, Max-Neef (1991), with his Human Scale Development proposal: an economic system based on measuring the satisfaction of fundamental human needs, instead of the Gross National Product (GDP), that nurtures self-reliance, and provides an organic articulation of people, nature and technology. On the other hand, Taoism can teach us the Tao, in English, the Way: the flowing, changing, spontaneous path of life aligned with the natural, harmonic rules of the constantly transforming cosmos. And here, the person and the Tao become One. Dualities disappear and are replaced with polarities: subject is also object, spiritual is also material, and human is also the environment. What is inside and what is outside is like one. This sense of oneness is not only a mystical experience but is also a wondrous revelation of modern physics (Timmerman, 1989; Miller, 2013; Capra, 2010), a perfect example of embodiment. Last but not least, indigenous knowledge can teach us about "strong transdisciplinarity": how to attain understanding by fusing empirical knowledge obtained from observation, traditional knowledge passed from generation to generation, and revealed knowledge acquired from spiritual insights (McGregor, 2004; Brant Castellano, 2000). This is a pivotal step towards fostering thinking in systems for a re-embodied era of holistic understanding.⁷ Strong transdisciplinarity could also lead us to "the progressive, firsthand acquaintance with the virtually of self' for the "ethical-know-how" (Varela, 1999, p. 63) we desperately need in the West.

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⁷ Max-Neef (2005b) understood the unification of this knowledge as "Strong Trandisciplinarity". He summarized it in what he called the three Laws of Trandisciplinarity, which go beyond embracing just levels of organization to embracing levels of reality for a genuine transdisciplinary education based on systemic thinking and the appreciation of complexity. The first law is that "the laws of a given level of reality are not self-sufficient to describe the totality of phenomena occurring at the same level" The second is that "every theory at a given level of reality is a transitory theory, since it inevitably leads to the discovery of new contradictions situated in new levels of reality? thus knowledge is always an open, changing process. Max-Neef explained that humans can access new levels of reality through the different levels of perception, with each level of perception corresponding to a level of reality. These levels of perception can be activated and enhanced through the practices of meditation and mindfulness, common practices in Taoism and Buddhism to achieve enlightenment. The third law is related to oneness, the unity of all things, and is based on the teaching of Lao Tzu, the Father of Taoism and the reputed author of the Tao Te Ching: "Only because of what is not there, it is possible that there is what is there; and only because of what is there it is possible that there is not what is not there.'

We can relate this new merging of science and religion to what has been referred to as Goethean science, from the work and writings of the German writer Johann Wolfgang von Goethe, dating back to the eighteenth and the nineteenth centuries: from the quest for accumulating more and more dissected data using a quantitative, disenfranchised language, to a quest for comprehending the integrated whole, which includes the qualitative contribution of the researcher or observer through his or her genuine perception of the boundless reality (Myers, 1997). As Max-Neef (2005b, p. 10) quoted from Jeremy Naydler (1996),⁸ for Goethe:

"[...] science is as much an inner path of spiritual development as it is a discipline of accumulating knowledge of the physical world. It involves not only a rigorous training of our faculties of observation and thinking, but also of other human faculties which can attune us as to the spiritual dimensions that underlies and interpenetrates the physical. Faculties such as feeling, imagination and intuition. Science, as Goethe conceived and practiced it, has as its highest goal the arousal of the feeling of wonder through contemplative looking (Anschauung), in which the scientist would come to see God in nature and nature in God."

Nowadays Goethean science can be related to quantum physics, and what Capra (2010) described as modern physics with a heart. Also, it can be related to Theology of Nature and Nature Theology, as described by Peters (2005), and the different non-western ancient cosmologies. Moreover, it can lead us to a new age of re-embodiment, what Berry (1991) called the Ecozoic Era. This means consolidating or synthesizing, as Wilson (1999) described it, the detached, self-contained disciplines as they are taught in schools and universities. Even the concept of spirituality is consistent with the notion of the embodied mind, introduced by the Chilean biologist, philosopher and neuroscientist Francisco Varela in the 1990s, and now being developed in the cognitive sciences (Capra and Luisi, 2014). Eastern religions, specifically Buddhism and Daoism, as well as indigenous knowledge around the planet, can shed some light on how to "shift

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⁸ Systems thinking or thinking in systems is holistic, integrated thinking which focuses more on understanding the wholeness of an organism or a phenomenon, including its connectedness, relationships, networks, patters, and context, in addition to its parts (Meadows, 2008; Capra, 2014).

the gears" of our Western disembodied culture, commencing with our educational and religious spheres. In these other ontologies we can find authentic embodied wisdom, which is what we need for effective ethics in the Anthropocene, because "ethics is closer to wisdom than to reason" (Varela, 1999, p. 3).

4. Conclusions

Recognizing the multiple natures of realities and narratives is the first step toward the re-configuration of the human-Earth relationship, without falling into the same mistakes of mainstream scientific and religious narratives: epistemic arrogance and the claim for a monopoly on the truth (Sideris, 2007). Thomas Berry (2003, p. 77) laid it out succinctly:

"It's all a question of story. We are in trouble just now because we do not have a good story. We are in between stories. The Old Story---the account of how the world came to be and how we fit into it—is not functioning properly, and we have not learned the New Story".

Religion and education are the foundation of the "grand-story" that is essential to change. This is because both are underlying forces in our cultural system, and as such are very important to help reinterpret and change the dominant story that feeds the system. They can help change the system's information flows, rules and goals for a paradigm shift, based on Meadows' (2008) proposals for systemic leverage points.⁹ So, from an ethical standpoint, the recommendation is to start from here, focusing perhaps on two basic transcendental questions, based on Max-Neef (n.d.), and Gare (2008a,b): What is life or the purpose of life? and What is our role in life or why do we exist? These questions, and our constant search for their answers, are pivotal for a grounded understanding of our place in the cosmos, as well as to have an adequate and non-distorted, bipolar story of

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⁹ Leverage points are "places in the system where a small change could lead to a large shift in the behavior" within the system (Meadows, 2008). Meadows recommends twelve influential areas to change the behavior of a system, and they all complement each other. A change in one will most probably provoke a change in another, like a chain reaction. Information flows (who does and does not have access to reliable information, missing information and adding or restoring information), rules (the scope, the boundaries or established limits) and the goals of a system are important leverage points to help trigger a paradigm shift.

who we really are. Even though we might never have a concrete answer for these questions because "our being is the product of an absolute improbability of being" (Max-Neef, n.d.), "their greatest value is in the questions they raise than the questions they answer" (Gare, 2008a, p. 14). The quest for the answer to these questions is rarely included in the curricula of the different disciplines taught in school that are intended to provide worthwhile existential goals and rules for life, and a reason to crave for learning and have a career.¹⁰ As E.O. Wilson (1999) framed it, to what end? What is our collective meaning and purpose? In the dawn of the seventeenth century, William Shakespeare also made it perfectly clear in his tragedy Hamlet: "To be or not to be, that is the question" is the famous first phrase of Prince Hamlet's soliloquy in Act III. What is subjective, qualitative and embodied -the opposite of what is objective, quantitative and disembodied- has had no place in most disciplines since the Age of Reason, in spite of the fact that "[t]here is a world in which you have to see in order to believe, and there is another world in which you have to believe in order to see" (Max-Neef, 2005b). We need societies capable of feeling wonder and awe for life and the world around them.

For centuries, we thought about the Earth. We were the subject of thought, and the Earth was the object and content. Now, after becoming conscious of the fact that the Earth and humanity form a single reality, it is important that we come to think as the Earth, to feel as the Earth, to love as the Earth (Hathaway and Boff, 2012).

What therefore becomes essential is the re-embodiment of the human mind, body, and soul and thus our models of reality (Gare, 2013 p.349; see also: Vatn, 2005; Daly and Cobb Jr., 1994; Westra et al., 2008). The Second Law of thermodynamics is a universal force that has yet to be integrated into the master-models that narrate human life today, and yet "we owe our very existence to the borrowed available energy of the Earth that makes up our physical being and that keeps us far away from an equilibrium state of death and decomposition" (Rifkin, 2009, p. 41). The Second Law is the fundamental reason why life entails death (Coffman and Mikulecky, 2012), and as the uniquely solitary species that is aware

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¹⁰ Only, and as a commonsense conclusion, we suppose they are as incorporated in the theological, philosophical and human behaviour-related disciplines, as they are in their discourses.

of this inevitable truth, while also maintaining sole responsibility for driving global environmental change at unprecedented levels, it is essential our species comes to terms with these realities through a profound shift in our death transcending methods (Solomon et al., 2003). Coffman and Mikulecky (2012) assert that the recognition of death as an inevitable part of life has generated a cognitive necessity for faith, which can be redirected towards a deeper metaphysical or spiritual relationship with life itself, in harmony with science, to transcend the individual experience and to persist the 'soul' of humanity. "We need this faith not only to overcome fear of death, but the repression through objectification that is at the root of so many of our problems. We need faith that, with time, humanity will develop a healthier mythology and culture - a better appreciation for the subjectivity of the world, and thus a greater empathy for the other" (Coffman and Mikulecky, 2012, p. 128). To achieve this paradigm shift from disembodied, objectified, ontologically arrogant narratives towards a respectful, pluralist, inclusive view of reality - education, science and religion undoubtedly have a decisive role to play. In the words of Giuseppe Barbiero (2016): "If the moral value of a pro-biophilic choice offers an advantage in terms of fitness [...], then nonviolence will be expressed, sooner or later, as a human generalised behavioural pattern. It is simply a question of time". On this matter, we share Barbiero's view.

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Authors' contributions statement

S.S. and S.M. conceived and wrote section 1. S.S. conducted the literature review and developed section 2; S.S. and S.M. wrote section 3; M.J. wrote sections 3.1; S.M. and M.J. wrote sections 3.2 and 4; S.M. provided critical feedback on all sections and revised the final draft.

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Reinterpreting intercultural dialogue for sustainability in the Anthropocene era

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- 1. Introduction
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- 5. Extending the narrative of the Anthropocene
- 6. Rethinking the Anthropocene through an intercultural dialogue lens
- 7. Concluding remarks

Keywords: intercultural dialogue; sustainability; Anthropocene; anthropocentrism; power relations.

Abstract. This article explores the concept of intercultural dialogue in an era shaped by significant human impact on the planet, commonly framed as the 'Anthropocene'. Addressing concerns that intercultural dialogue may be limited to human-centered interactions, the article argues that the Anthropocene narrative offers a critical and imaginative reassessment of intercultural dialogue, extending its scope beyond traditional anthropocentric perspectives. Furthermore, the article suggests that critically rethinking intercultural dialogue within the context of the Anthropocene can, in turn,



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lead to a more nuanced understanding of the Anthropocene narrative itself. Central to this argument is the need for a critical analysis within the Anthropocene discourse, highlighting how a small group of nations disproportionately contributes to climate change while the world's most vulnerable communities bear the consequences. By situating intercultural dialogue within an ecological context, the article underscores its potential to challenge dominant narratives, amplify marginalized voices, and thus foster more just and sustainable ways of coexisting. Ultimately, the article calls for a deeper recognition of the interconnectedness of human and non-human life, ensuring that environmental awareness becomes a central component of intercultural communication and collaboration.

1. Introduction

In this paper, I explore the opportunities for understanding intercultural dialogue in a way that goes beyond its traditional anthropocentric approach. More specifically, I draw attention to how the 'Anthropocene' narrative disrupts the conventional notion of intercultural dialogue and discuss the potential for reimagining such a concept within a context where human activities are having increasingly detrimental impacts on the world (Biswas Mellamphy & Vangeest, 2024; Malm & Hornborg, 2014; Zalasiewicz et al., 2009). At the same time, I analyse how a wider understanding of intercultural dialogue can contribute to a more nuanced comprehension of the Anthropocene narrative itself, underlining the necessity to incorporate perspectives on structural injustice and global power structures. The research question for this paper is as follows: *How can a reciprocal critique of intercultural dialogue and the Anthropocene narrative foster sustainable intercultural relations in an era of global environmental change?*

The article is structured as follows: First, I provide a contextual background for the discussion by drawing attention to two key initiatives – the European Union's launch of *The European Year of Intercultural Dialogue* in 2008, and, a few months later, the Stratigraphy Commission of the Geological Society's proposal of the term *Anthropocene*. Next, I continue by formulating a central challenge for understanding intercultural dialogue in the Anthropocene: the need to critically examine how anthropocentrism shapes and structures intercultural encounters. I

then explore how the Anthropocene can serve as a productive concept for a critical and constructive rethinking of intercultural dialogue, incorporating environmental awareness into contemporary discussions on intercultural interactions. Following this, I consider how an expanded concept of intercultural dialogue – one that includes marginalized voices from both nature and culture – can contribute to critical research seeking a deeper understanding of the Anthropocene. I conclude the article by reflecting on the importance of broadening the discussion of the Anthropocene beyond the natural sciences, emphasizing that integrating intercultural dialogue into this narrative enriches the discourse and underscores the need to reconnect humanity with the broader biosphere.

2. Two defining narratives of the 21st century - Contextual background

In January 2008, in Ljubljana in Slovenia, the European Parliament and the member states of the European Union (EU) launched 'The European Year of Intercultural Dialogue' (The European Union, 2008). Initiated as an awareness campaign to encourage and enhance debate and reflection in and between EU countries, the year resembled an almost 40-year tradition where the European Commission proposes a specific thematic issue which is then adopted by the Parliament and the EU member governments. The background and context for this particular program was the successive enlargement of the EU and the increasing globalization and internationalization that many of the European countries had experienced in recent years. For that reason, the main aim of the year was "to raise the profile of intercultural dialogue, which is essential for creating respect for cultural diversity, improving coexistence in today's diverse societies and encouraging active European citizenship" (The European Union, 2008, p. 2). Through such a priority, the EU wanted to recognize the advantages of cultural diversity and to emphasize the crucial need for handling cultural differences between human beings in a way that leads to social cohesion and peaceful coexistence.

A month later, in February 2008, members of the Stratigraphy Commission of the Geological Society, an interdisciplinary group of geoengineers and chemists, came together in London to publish a short but groundbreaking paper that was to create a massive debate in the years to come. In the paper entitled "Are we living in the Anthropocene?" the authors suggested that "earth has endured changes sufficient to leave a global stratigraphic signature distinct from that of the Holocene" (Zalasiewicz, et al., 2008, p. 4). Re-introducing the term

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'Anthropocene', the authors proposed a shift from the current geologic epoch, the Holocene, to a new epoch in the history of the world. While the Holocene began around 12.000 years ago after the last major ice age, the Anthropocene describes the most recent period in earth's history when human activity started to have a dominant influence on the planet's climate and ecosystems (Liana & Fair, 2019). As noted by the Stratigraphy Commission, evidence of "the global environmental effects of increased human population and economic development" (Zalasiewicz, et al., 2008, p. 4) is now overwhelming, including a significant rise in average global temperatures, increasing sea level, a growing volume of waste, and an accelerated loss of biodiversity due to extinctions of plants and animals. Hence, according to the authors, recognizing the shift from the Holocene to the Anthropocene marks a crucial step towards fostering greater ecological awareness regarding how human actions impact environments and global lifeforms (Zalasiewicz, et al., 2008).

When first considered together, the European Intercultural Dialogue Year and the Anthropocene statement reflect quite disparate agendas. While the EU commission (The European Union, 2008) aims at strengthening "respect for the equal dignity of all human beings" (p. 19), and "promoting human rights" (p. 8), the Stratigraphy Commission (2008) argues strongly against human supremacy where human interests are privileged over nonhuman forms for life. In both cases, however, human beings are seen as part of the solution, whether it is to foster peaceful and constructive coexistence through dialogue, or to reduce the harmful impact humans have on the climate. As such, both initiatives signalize a shared belief in human beings' ability to influence and transform their local and global contexts.

However, in this article I will argue that the two concepts represented in these initiatives also hold the potential for mutual critique, a perspective often overlooked in debates on fostering sustainable intercultural relations in an era of global environmental change (Bergmann, 2020; Milstein & Castro-Sotomayor, 2020; Simangan, 2020). In the article, I argue that that the Anthropocene narrative offers an opportunity for a critical reevaluation of intercultural dialogue, transcending its traditional anthropocentric focus. Simultaneously, interpreting intercultural dialogue through an Anthropocene lens can contribute to a more nuanced and refined understanding of the Anthropocene itself. Specifically, the idea that intercultural dialogue addresses marginalized voices and aims for equitable power distribution highlights hidden power dynamics within the Anthropocene narrative.

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3. Intercultural dialogue and anthropocentrism

The concept of intercultural dialogue has a longstanding history that predates the current discussions on how to address the growing and varied forms of diversity in contemporary multicultural societies (Elias & Mansouri, 2020; Skrefsrud, 2016). In recent years, however, the concept has gained a foothold in Western literature and research, particularly following the significant attention towards intercultural dialogue at the European policy level (Council of Europe, 2008, 2013; The European Union, 2008; UNESCO, 2022). In a context of growing anti-immigration attitudes, a perceived lack of integration of minorities, and increased level of polarization, the Council of Europe (2008) addressed the need for "an open and respectful exchange or interaction between individuals, groups and organizations with different cultural backgrounds or world views" (p. 17), urging dialogical initiatives "to develop a deeper understanding of diverse perspectives and practices; to increase participation and the freedom and ability to make choices; to foster equality; and to enhance creative processes" (p. 17). Within the context of the European Union, the concept of intercultural dialogue has thus been seen "as one of the main instruments of peace and conflict prevention" (Wilk-Woś, 2010, p 86) and a significant tool for shaping human society. Hence, at the European policy level, intercultural dialogue serves both as a concept to guide policy construction and as a political instrument to encourage and establish cross-cultural interactions and communication for peaceful human co-existence.

Nevertheless, as noted by scholars such as Jia and Jia (2016), Kinefuchi (2018), and Phipps (2014), there is a pressing need to investigate the concept of intercultural dialogue, exploring both its developmental potential and its limitations and qualifications. One prominent critique has been raised by Phipps (2014), questioning the idealized meaning of intercultural dialogue in contemporary policies. As intercultural dialogue has become a leading term – and even a buzzword – in European policy discussions, Phipps (2014) contends that the concept "is at its best a problematic and largely inoperable under present conditions of globalization" (p. 113). By this, she means that the concept of dialogue is not designed for times of conflict, but rather for "depoliticized and normatively conservative conditions" (Phipps, 2014, p. 122). Within the European policy context, the concept reflects the "post-war aspirations of that the United Nations would function to secure peace between nations through dialogues and negotiations" (Phipps, 2014, p. 114). For that reason, Phipps argues that the concept needs to be reconstructed and adapted to a contemporary

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reality of vulnerability, insecurity, and aggression towards humans and their surroundings.

An important part of this critique has been the lack of global awareness within the conceptualizations of intercultural dialogue (see for example Holmes, 2014; Kinefuchi, 2018; Milstein & Castro-Sotomayor, 2020). As the notion of intercultural dialogue is being emptied of content and reduced to a slogan for political enterprise, there is an urgent need for intercultural scholarship to face the anthropocentric forces that have contributed to the current planetary-wide ecological destruction. As argued by Kinefuchi (2018, p. 213), in order to stay relevant, all fields should "continue to be reflexive and adapt to the changes and needs brought about by given historical contingencies". Hence, according to Kinefuchi (2018), research on intercultural dialogue should critically acknowledge that human activity is influencing the world's ecosystems to the extent that it appears to be the central driver of environmental change. Conceptualizations of intercultural dialogue should, therefore, extend beyond a narrow focus on anthropocentric concerns. and Earth's natural landscapes and eco-systems.

Within this background, a central challenge in conceptualizing intercultural dialogue within the Anthropocene is acknowledging the potential tension that may arise, not only between individual freedom and community rights but also between human well-being and environmental concerns, such as the care for animals and other species. Thus, reinterpreting intercultural dialogue within this context suggests a need for action to safeguard the health of the planet and foster peaceful prosperity for all its inhabitants. With this in mind, I now turn to the question of how the Anthropocene narrative can contribute to reshaping intercultural dialogue by integrating critiques of anthropocentrism. What insights can be gained from this critique when reconsidering the concept of intercultural dialogue?

4. Rethinking intercultural dialogue through an Anthropocene lens

A key component of the Anthropocene narrative is the argument for a common moral space to which all organisms and their environments belong (Malm & Hornborg, 2014; Zalasiewicz, et al., 2008). Moving from the Holocene to the Anthropocene era, relations between humans and the environment are no longer dynamic and reciprocal. Rather, human actions, particularly since the onset of industrialization, have greatly affected the environment, frequently in harmful ways. Activities such as pollution, deforestation, and ecological destruction thus

shows a predominantly one-sided and often damaging relationship with nature. As noted by Malm and Hornborg (2014), human beings have ascended to power over the rest of the ecosystem, suppressing plants, animals and other species by distancing humanity from the biosphere. Re-discovering the interconnectedness of all living beings and their ecosystems, would therefore be a way to embrace a shared moral space that acknowledges the intrinsic value of all forms of life.

Consequently, the Anthropocene narrative highlights a profound attentiveness towards voices from the margins, encouraging thinking and practices that give voice to ecological victims of cultural human violence (Zalasiewicz, et al., 2008). Recognizing the transition from the Holocene to the Anthropocene is an urge to writing a new common history, making biological species visible, and acknowledging their fight for survival under human destruction. In this sense, interpreting the world around us would involve an incorporation of the experiences of marginalized voices and critically examining the systems and practices that suppress their knowledge, perspectives, and histories. In contexts where the impacts on future biological life processes are largely overlooked, listening to these marginalized voices serves as a reminder of our shared biospheric history, which includes both the oppressors and the oppressed throughout cultural and natural history (see also Bergmann, 2003).

From the perspective of the Anthropocene narrative, nurturing and encouraging such a listening to voices from the margins – also in an ecological sense – will impact all conceptual thinking, including understandings of intercultural dialogue. Because the ecological shift challenges the notion that human beings should be regarded as external to the environments they inhabit (see also Fitzhugh, et al., 2019), the field of intercultural dialogue must broaden its scope beyond exclusively addressing anthropocentric issues. Interpreting the concept of intercultural dialogue in the Anthropocene prompts an inquiry into how dialogical initiatives for sharing and learning across differences can be formed in ways so that they caretake both a sustainable ecological and social development. As noted by Malm and Hornborg (2014, p. 62), "now that humanity is recognized as a geological force", voices from the margins - also those voices in nature that have been subjected to violence through human beings' destruction of Earth should be heard and accounted for in intercultural dialogues. Consequently, rethinking the notion of intercultural dialogue in light of such a perspective, would challenge understandings of the dialogue concept in at least three specific ways.

First, broadening the scope of intercultural dialogue beyond human-centered concerns would encourage the actors who participate in intercultural encounters

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to see the interconnections between their everyday lives and the environmental surroundings they share (Simangan, 2020). Intercultural dialogues would thus include attention towards how environmental degradation and climate change disproportionately affect certain communities, particularly those already marginalized. Such a critical awareness could also make intercultural dialogues more practice-oriented, urging participants to act upon their own knowledge, and to not only identify, but also confront mechanisms that maintain the social and cultural inferiorization of minoritized groups. By incorporating environmental concerns, intercultural dialogue becomes a platform for discussing shared ecological responsibilities, fostering a more holistic understanding of coexistence between human cultures, human experiences, nature, and the planet.

Second, the invitation from the Anthropocene narrative to a more inclusive understanding of whose voices are being heard in dialogue, holds the potential of reframing marginal voices in an empowering way. To advocate for a more ethical and interconnected understanding of intercultural dialogue acknowledges the rights of both human and non-human beings. By doing so, marginalized voices are not just perceived as victims of environmental degradation but as critical and constructive contributors to the solutions and narratives of resilience needed in the Anthropocene era. In contrast to what Bhabha (1994) framed as "the colonizer demand for narrative", where the majority controls the minority by letting their voices be heard, the Anthropocene critique alters the power distribution in such a way that the victim is no longer a victim but an equal participant.

Third, the inclusion of ecological concerns in conceptualizations of intercultural dialogue would also provide audience and resonance for marginalized voices. As Lundy (2007) has emphasized in her prominent model on children's participation, being given a space to let one's voice be heard is not enough. Rather, it is through the engagement of an audience that frequently unheard voices can express their unique perspectives, experiences, and challenges. Resonance, in this context, refers to the ability of these voices to emotionally and intellectually connect with an audience, creating an impact that extends beyond the immediacy of their narratives. Lundy (2007) noted that when such voices resonate with an audience, it holds the potential to foster empathy, understanding, and ultimately, social change. Accordingly, by facilitating spaces of resonance, the audience can bear witness to these narratives, validate the experiences, and serve as agents in carrying forward the dialogue initiated by marginalized voices. Cuevas-Parra (2022) emphasized that the incorporation of audience and resonance in the understanding of participation makes it possible

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to analyze "the different degrees of participation that can take place in relation to meaningful spaces, negotiation of power, decision-making and shared responsibilities" (p. 365). In a similar vein, by incorporating the Anthropocene critique in intercultural encounters, the resonance of marginalized narratives from all subordinated voices has the power to broaden perspectives, incite introspection, and inspire action.

5. Extending the narrative of the Anthropocene

So far, I have discussed the potential of the Anthropocene narrative for a critical and constructive rethinking of intercultural dialogue. However, as I will show in the following part of the article, a critical incorporation of the Anthropocene narrative into the discourse on intercultural dialogue requires an examination of the Anthropocene narrative itself.

While there is substantial value in the Anthropocene consensus regarding humanity's exploitation of the planet, Bergmann (2020), Malm and Hornborg (2014), and others have emphasized the need for a deeper and more nuanced understanding of the normative ambitions embedded in the Anthropocene narrative. According to Bergmann (2020), such an understanding requires further reflection on how "the all-embracing impact of humans leads to a new humility towards both human and other life forms" (p. 162). Hence, from the perspective of Bergmann, acknowledging humanity's role in the destruction of the planet is not sufficient. The Anthropocene narrative requires a new humility in recognizing the impact humans have had – and continue to have – on the environment, along with a commitment to reevaluating the relationship with the natural world.

One prominent part of this new humility would be to critically reflect upon the very concepts we use to describe and discuss human-driven destruction of other species and life forms, including the Anthropocene. In this regard, several scholars have problematized the centrality of the 'anthropos' in the Anthropocene (Biswas Mellamphy & Vangeest, 2024; Kopnina, 2019). Although the Anthropocene era is defined as a human-dominated geological epoch, a key critique has been the inherent paradox that the concept itself reinforces human superiority. As noted by Biswas Mellamphy and Vangeest (2024), "discussions of the Anthropocene promote humanistic attempts to 'manage,' 'engineer,' or 'guide' the geological timescale, with humans 'optimizing' climate change toward 'sustainable ends''' (p. 601). Hence, Biswas Mellamphy and Vangeest (2024)

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in policy documents, climate reports, and certain scientific discourses, particularly in fields like geoengineering, climate modeling, and Earth system science – often frame humans as the central agents of control over environmental and geological processes. Discourses surrounding the Anthropocene assumes that humans have the capability – and even the obligation – to control and govern the planet's geological and ecological future. According to Biswas Mellamphy and Vangeest (2024), this reflects a continuation of anthropocentrism, where human intervention is seen as the primary solution to environmental crises. As such, anthropocentrism, either in a strong or weaker sense, remains an important part of the standard and dominant narrative of the Anthropocene.

Furthermore, such an inherent anthropocentrism runs the risk of treating climate change as a problem that can be technologically fixed rather than questioning the underlying political, economic, and ethical structures that caused environmental destruction in the first place. The critique from Bergmann (2020), Biswas Mellamphy and Vangeest (2024) and others, suggests that we need to move beyond the idea that humans should engineer the planet toward sustainable ends. Instead, they invite a more ecologically and ethically grounded approach – one that questions the underlying assumptions of human dominance and acknowledges the agency of non-human life, ecosystems, and planetary processes.

Such an invitation includes acknowledging that "the majority of the planet's poor are suffering from the violence of ongoing climatic change caused by a minority of countries" (Bergmann, 2020, p. 164). As such, we see a call for a critical reflection that moves beyond merely recognizing and critiquing anthropocentric superiority. Seeking a more nuanced and complex perspective challenges us to reconsider how the Anthropocene narrative may create blind spots, obscuring the structural inequalities and power imbalances that shape environmental crises.

6. Rethinking the Anthropocene through an intercultural dialogue lens

From this perspective, I believe that embracing an ecologically grounded conceptualization of intercultural dialogue has the potential to address and expose the global power imbalances that the Anthropocene narrative may overlook or even reinforce. In the following and final section of this article, I identify three interrelated perspectives on how an eco-friendly intercultural dialogue can critically challenge dominant Anthropocene assumptions and offer alternative ways of understanding human-environment relationships.

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First, as noted above, the Anthropocene concept is often critiqued for reinforcing anthropocentrism – the idea that humans are the central and most significant actors in shaping the planet. Paradoxically, and contrary to what was the original idea when members of the Stratigraphy Commission of the Geological Society (Zalasiewicz, et al., 2008) reintroduced the Anthropocene term, this perspective tends to frame environmental issues in terms of human needs, economic systems, and technological solutions while sidelining the intrinsic value and agency of non-human life. Within this context, a revised concept of intercultural dialogue provides a space to challenge these assumptions by integrating diverse worldviews that see humans as part of, rather than above, nature.

Second, as I identified above, a major issue with the Anthropocene narrative has been that it often promotes a technocratic and market-driven solution to the environmental crise. Many dominant responses to the Anthropocene rely on technocratic fixes, such as geoengineering, carbon markets, or AI-driven sustainability efforts. Hence, this approach to the Anthropocene assumes that humans can control, manage, or 'fix' planetary systems through scientific innovation, economic incentives, and large-scale interventions, often ignoring deeper ethical, cultural, and ecological considerations. While these solutions may seem promising, they often fail to address the root causes of ecological crises, such as overconsumption, extractivism, and global inequalities. Thus, an ecofriendly intercultural dialogue raises several critical concerns about this technocratic mindset, for example the idea that humans can control complex ecosystems. However, history shows that large-scale engineering projects (e.g., industrial agriculture, dams, etc) frequently create new environmental problems rather than solving them. Many technological solutions also focus on quick fixes rather than deep, systemic changes. For example, may carbon capture technologies reduce emissions in the short term but fail to challenge the overconsumption and economic structures that drive climate change. Moreover, while market-driven solutions often shift responsibility away from large-scale polluters and onto individuals or marginalized communities, an eco-friendly intercultural dialogue exposes their limitations and ethical problems. As such, a revised concept of intercultural dialogue can challenge the Anthropocene's technocratic and economic focus, shifting the conversation toward ethical, relational, and ecologically sustainable ways of living. Rather than seeking to optimize the planet for human convenience, an eco-friendly intercultural dialogue reframes sustainability as a collective, ethical responsibility that includes both human and non-human life.

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Third, by fostering attentiveness to a broader spectrum of voices – including the marginalized voices of plants, animals, and other species – an ecologically oriented intercultural dialogue reminds us that some actors are more at risk than others when striving to cultivate a socially just and responsible global community. In their critique of the Anthropocene narrative, Malm and Hornborg (2014) underscored that the Anthropocene often fails to highlight global inequalities in environmental impacts and responsibilities, overlooking the divide between how the Global North and Global South contribute to and suffer from ecological degradation. Industrialized nations have historically been the largest polluters and resource consumers, while the Global South bears the brunt of the environmental fallout, including rising sea levels, extreme weather events, and biodiversity loss. In this context, an ecologically oriented intercultural dialogue can inspire critical awareness of the historical and ongoing exploitation of land and resources in colonized or developing regions and how this inequalities shape both environmental and cultural realities.

7. Concluding remarks

The purpose of this article has been to discuss and explore a reinterpretation of intercultural dialogue in the Anthropocene. By using the term *in*, I have aimed to signalize that intercultural dialogue initiatives are not situated outside the critical discourse on humans' dominant influence on the planet. Rather, as a human activity, intercultural dialogues take place *within* the Anthropocene and, as such, should be subject to critical restructuring amid the ongoing anthropogenic transformations of the Earth's atmosphere and ecosystems (see also Bergmann, 2020).

My argument has been that both the concept of intercultural dialogue and the Anthropocene narrative can mutually enrich one another when critically reflecting on what it means to foster peaceful, constructive, and sustainable coexistence in a changing world. At a time when global power struggles disrupt traditional peace efforts, misinformation and identity politics deepen divisions, and public trust in institutions is eroding, rethinking intercultural dialogue is more urgent than ever (Kinefuchi, 2018; UNESCO, 2022). Sustainability cannot be separated from these broader crises, as climate action, resource equity, and ecological justice are deeply intertwined with political instability, cultural tensions, and institutional distrust. Learning from the Anthropocene narrative – particularly its emphasis on recognizing the voices of nature when acknowledging the ecological destruction caused by human impact – intercultural dialogue can

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more effectively address the recurring critique of anthropocentrism. In doing so, intercultural dialogue can better serve as a transformative force, helping to bridge divides and cultivate trust in the pursuit of a more just and sustainable future.

Furthermore, although the Anthropocene narrative has fundamentally reshaped how we understand human-environment relationships, it also carries a set of problematic assumptions that demand critical reflection. While it is undeniable that human activity has led to significant ecological disruptions, the framing of the Anthropocene often reinforces a hierarchy in which humans are positioned as managers, engineers, or even saviors of the planet. This perspective risks sidelining the intrinsic value and agency of non-human life while also overlooking global power inequalities. Although discussions about climate change and environmental degradation within the Anthropocene framework often focus on humanity as a collective, the reality is that environmental destruction has been disproportionately driven by industrialized nations and corporate interests, while marginalized communities - particularly in the Global South - bear the consequences. As such, an eco-friendly intercultural dialogue can challenge the Anthropocene's anthropocentric, technocratic, and market-driven biases by acknowledging the specific actors, histories, and structures that have fueled - and continue to fuel - ecological crises, rather than treating humanity as a homogenous force. By recognizing the rights, agency, and intrinsic worth of ecosystems, animals, and other non-human actors, intercultural dialogue brings to the forefront the voices of those who have historically been silenced or excluded from environmental decision-making.

There is significant value in fostering a broader conversation around the Anthropocene. When disciplines beyond the natural sciences engage with the Anthropocene narrative, its relevance and practical implications can be further theorized and translated into actionable insights. For intercultural dialogue, such engagement situates what Simangan (2020) describes as "narratives of vulnerability and historical injustice, the non-modernist understanding of nature, [and] the agency of the vulnerable" (p. 211) within the Anthropocene discourse. By amplifying these perspectives, intercultural dialogue can expand and diversify discussions on the Anthropocene, reinforcing its significance in this new geological era. At the same time, embedding the concept of intercultural dialogue within the Anthropocene framework strengthens the recognition of ecology as an inseparable context for human interaction and communication. In doing so, intercultural dialogue challenges us to move beyond narratives that depict human cultures as distinct from – or superior to – the natural world.

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The representation of nature in a political speech in promoting "Indonesia Maju"

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- 1. Introduction
- 2. Related literature
- 3. Methodology
- 4. Results and Discussion
 - 4.1. Ideational meaning in Joko Widodo's State of the Nation address on 16 August 2022
 - 4.2. Actants in the quest for advanced Indonesia
 - 4.3. Advanced Indonesia as destructive discourse
- 5. Conclusions

Keywords: actantial; discourse; ecolinguistics; transitivity.

Abstract. In spotlighting the relationship between human and nature, ecolinguistics offers a working approach. It requires linguistic data from the language choices in portraying nature in various texts, including political speeches. Topics on nature in political discourse and speeches are strategic not only to gain people's attention but also to hide agendas. They commonly conceal commodification of natural resources and exploitation under the national advancement and stability. This research intends to reveal the



destructive discourse on nature by incorporating Systemic Functional Grammar's transitivity and Greimas' actantial analysis. The research object is the former Indonesian President Jokowi's speech which promotes the notion of "Advanced Indonesia". Linguistically, the speech emphasizes green economy but neglects indigenous people and environmental concerns. The result shows that the most frequent transitivity processes are material process by 61% and relational process by 29%. They indicate that ideologically the speech focuses on actions, happening, and connections of ideas. However, the material process hides the responsible actors by passive voice sentence construction. The relational process highlights Indonesia as a successful country in overcoming Covid-19. By the actantial analysis, in achieving "Advanced Indonesia" as the goal the speech neglects the nature by maintaining anthropocentric perspectives of the subject.

1. Introduction

Political language, language used by politicians, in any of its forms, including speeches, slogans, or posters can be a subject to scrutiny (Kuha, 2018). It is employed to exert control over people. Political speeches can be considered political action aimed at upholding government policies or the current social order (Li et al., 2020). Political commemorative speeches pertain and exercise power and authority (Reisigl & Wodak, 2016). Political speeches, like the president's speeches, use language to endorse the president's agenda. In doing so, political speeches often showcase emotions in promoting political initiatives, programs, and ideas in every community (Dylgjeri, 2017). For instance, political speech might evoke people feelings and attitudes towards the country, such as people's nationalistic pride. Feeling proud of one's country might stem from a desire for a shared history and memories, creating a sense of belonging to a 'tribe' over time (Charteris-Black, 2018). Joko Widodo or Jokowi, the former President of Indonesia, delivered a speech on August 16, 2022, promoting a national vision called Indonesia Maju or Advanced Indonesia, which he coined and introduced in his second presidential inauguration on October 20, 2019 (Hartanto et al., 2021). The speech showcases a sense of belonging to win the people's sympathy by the use of inclusive pronoun 'we' as he mentioned "we must continue with the

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nation's big agenda to achieve an Advanced Indonesia" (Widodo, 2022). Jokowi invited the people of the republic to support the realization of an Advanced Indonesia. Even the logo of the 78th Indonesia Independence in 2023 says *Terus Melaju untuk Indonesia Maju* (Keep Moving for the Advanced Indonesia). Therefore, the notion of Advanced Indonesia has been placed in a national discourse and was designed and built on Indonesian national development narrative by the president of Indonesia.

Indonesian national development in the speech was echoed by mentioning a green industrial park being built in North Kalimantan as the world's largest economy-wise park. The president stated, in a press conference, the electricity to manufacture EV batteries, petrochemicals, and aluminum in the park will be supplied from the hydropower from *Mentarang* and *Kayan* River in North Kalimantan (Widodo, 2023). North and East Kalimantan are part of the Heart of Borneo, noted for their biodiversity, and both regions sustain forest life, water supply, carbon storage, cultural significance, and ecotourism (HoB, 2019). The park affects the indigenous inhabitants of *Long Lejuh* and *Long Peleben* in *Bulungan* Regency which are set to be submerged for the sake of hydroelectric infrastructure (Siagian, 2022). The impacts on the nature and the indigenous inhabitants are alarming. The alarm invites the researchers to examine and investigate Jokowi's speech linguistically.

The linguistic examination and investigation employ Systemic Functional Grammar's transitivity analysis. Transitivity analysis provides a critical and rigorous linguistic analysis in analyzing text. It identifies processes, participants, and the circumstances in clauses and categories them into their functions. The analysis can reveal that ecological discourse can refine participants' roles in construing good, neutral, and harmful ecological standpoints (Stibbe, 2021a; Zuo, 2019). This present research also aims at deciding whether the research object is beneficially good, neutral, or harmful to the ecology.

Some research also went in a similar direction with this present research in evaluating texts ecolinguistically. Jokowi's speech on August 17, 2022, was analyzed by a pragmatic approach scrutinizing how the uses of deixis types contributed to developing his concerns about various aspects of life to achieve "Indonesia Maju" (Manik et al., 2023). United Nation's Secretary-General's climate change speeches is found encouraging people to reduce natural devastation to combat climate change (Wang et al., 2019). The speeches were considered beneficial to the ecology. On the other hand, texts and discourses can be destructive. For instance, Isti'anah conducted an ecolinguistics analysis shows that Wonderful Indonesia's articles about Yogyakarta predominantly

promote tourism and social environment by diminishing the role of the natural environment. Indonesian tourism websites should focus more on local people and tourists' environmental engagement (Isti'anah, 2020). Jokowi's speech at the 21st Conferences of the Parties in Paris (2015), for instance, was noted as a beneficial discourse as it raised awareness of ecological issues (Mansyur et al., 2021). The research employed transitivity analysis but did not explore erasure, salience, and framing as suggested by ecolinguistic approach. This present research intends to fill in the academic gap by examining a political speech through the ecolinguistics lenses.

There is a need to conduct transformative environmental politics by providing critics with the granted structure (Hammond, 2020, 2022; Machin, 2020). This research contributes to ecological discourse analysis by demonstrating how the transitivity process idealizes the narrative actants structured in a discourse to address the problematical use of language that is detrimental to the environment. Therefore, this present research seeks the answer of how the ideational meaning of *Indonesia Maju* or *Advanced Indonesia* contained in the Jokowi's speech, how is nature positioned in the actantial configuration of the discourse narrative, and whether the ideology of *Indonesia Maju* or *Advanced Indonesia* beneficial, destructive, or ambivalent to the nature.

2. Related literature

Language, as proposed by Sapir and Whorf, enacts a worldview that conceptualizes human experience (Goatly, 2018). Language, therefore, connects the linguistic symbols with the surroundings and environments. The significance of language lies in its influence on human interactions, as well as interactions with other animals and the environment (Alexander & Stibbe, 2014). Ecolinguistic analysis explores the language patterns to reveal people's thoughts, concepts, ideas, ideologies, and worldviews which influence the way of thinking and treating the environment (Stibbe, 2021a). Ecological Discourse Analysis (EDA), a key paradigm in ecolinguistics, focuses on the social system and its impact on the entire ecosystem. It also wants to encourage people to think about and fix the ecological crisis, which will raise awareness about protecting the environment and help the system balance (Zhang et al., 2023).

Erasure is a notion in ecolinguistics. Ecolinguistics intends to spotlight what is absent in the human experience including the role of environment in the discourse promoting consumerism in the industrial society (Stibbe, 2014, 2021a). The value of that something differs according to the goals and interests of the

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speaker or the writer who reprises. Thus, what is worth attention to usually appears as a salience pattern in texts delivered through concrete and detailed descriptions (Alexander & Stibbe, 2014; Stibbe, 2021a). Also, a discourse is usually built within a frame that brings ideas to mind with chosen triggering words, especially the framing of 'sustainable development' that is appropriated to boost economic growth (Stibbe, 2021b, 2021a). This perspectives integrates linguistic study and other disciplines to challenge the unsustainable society (Stibbe, 2021b). It resists discourses that contradict values of ecosophy which involves the notions of valuing living, wellbeing, present and future, care, environmental limits, social justice, and deep adaptation (Stibbe, 2021a).

Maintaining hegemonic powers typically requires specific rhetorical techniques where technocratic and bureaucratic naturalization is fostered by language users' rhetorical activation of linguistic constructions (Alexander, 2018). Discourses containing linguistic features are employed by communities to generate certain reality models when they converse about the outside world (Tatin, 2024). Ecolinguistics examines reality models and their linguistic components because they enable individuals to interact with the physical world (Wu, 2018).

Critical discourse studies are encouraged to consider the use of narratives that shape identities and the social conduct of the world (Forchtner, 2021). Ecolinguistics studies use a critical viewpoint to speak for the environment, which people only see and address through language. Narrative analysis uses aspects including setting, audience, goal, and viewpoint to reveal the human experience (Wertz et al., 2011). Meanwhile, the composition of the narrative is made by the interplay among elements which are the verbs used in the strings and the pattern of conflicts in the text (Herman, 2002). As mentioned before, this present research directs the analysis to see how the environment is positioned in a political speech. When analyzing the discourse of a political speech, particularly during state commemorations, examining how the environment is framed within the national agenda becomes critical and central.

A discourse is developed through narrative acts where there are processes of roletaking that produce mental mapping (Plummer, 2019). Furthermore, seeing discourse as narrative, as Abbot in 2002 reasoned, invites us to see how human beings arrange events not only chronologically but causally in a way that places them in the circumstances (Forchtner, 2021). Narratives include participants negotiating the relationship between the present interaction place, time, and group of individuals with a separate there-and-then speaking event where participants are negotiated (Koven, 2015). Actantial roles are associated with characters (actors) at the surface or discursive level, the action is positioned in

time and place, and values are developed into themes (thematization) that Greimas calls figurativisation (Boklund-Lagopoulou, 2018). Thus, the aspect of narrative building is essential to the delivery of discourse which reshapes the perspective of reality to serve one's goal.

Actantial analysis is employed to examine the relationship as represented by the language used in the body of the speech text. Actantial analysis helps clarify discourse meaning and reveal narrative substance (Max et al., 2023). It is through the actantial analysis, according to Barthes, that the participant in certain actions can be exposed as it provides the structure of sender, receiver, subject, object, opponent, and helper (Fabbri, 2022). It is because including and excluding things are done to serve different interests from which a sense of reality is made (Leeuwen, 2016). This allows examination of Advanced Indonesian discourse interactions. Greimas' actantial approach sees narrative discourse as semiologically and semantically involved beyond sentences and grammar since predicates establish actants and their accomplishments regardless of language (Schleifer, 2017).

As this research is also text analysis, Systemic Functional Linguistics (SFL) is applied because it directs a consistent and dependable mark for a transdisciplinary framework (Fontaine & Wegener, 2023). In Hallidayan SFL, language in use performs simultaneously three functions (ideational, interpersonal, and textual). Here, the focus is on the ideational functions that manifest in the transitivity processes embedded as semantic properties of the verbs that appear in clauses (Bloor & Bloor, 2004). SFL is chosen for three reasons. First, it can describe grammar's meaning-making function well. Second, it follows social constructionism, which holds that context and culture shape meaning. Third, it offers an applicable linguistics with categories to rate language expressions (Lei, 2021).

3. Methodology

The data source is from the speech entitled State of the Nation Address of the President of the Republic of Indonesia at the Annual Session of the People's Consultative Assembly (MPR) of the Republic of Indonesia and the Joint Session of the House of Representatives (DPR) of the Republic of Indonesia and the Regional Representative Council (DPD) of the Republic of Indonesia on the Occasion of the 77th Anniversary of the Proclamation of Independence of the Republic of Indonesia (*Pidato Presiden RI Pada Sidang Tahunan MPR RI dan Sidang Bersama DPR RI dan DPD RI dalam rangka HUT Ke-77 Proklamasi Kemerdekaan RI*,

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di Gedung Nusantara MPR/DPR/DPD RI, Senayan, Provinsi DKI Jakarta, 16 Agustus 2022). The English script of the speech can be read on www.setkab.go.id from the page managed by the Office of Assistant to Deputy Cabinet Secretary for State Documents & Translation. It was uploaded on 16 August 2022.

The arrangement of processes and participants in a clause reveals how subjects relate to objects or processes and examines how individuals and others construct, negotiate, and challenge different worldviews, including attributions of responsibility for actions and events (Jørgensen & Phillips, 2002). It is also useful to see whether the participants in the clause are given an active role or a passive role (Stibbe, 2021a).

Transitivity processes are analyzed by each type because there is a notion that the practical use of language is to represent the world as it is perceived or imagined so that experience is encoded in it as ideational meaning (Bloor & Bloor, 2004). First, any verbs carrying material process signify the various kinds of actions. To be more precise, the term "action" incorporates both tangible and intangible social behaviors (Bartley, 2018). The material process deals with two further sub-processes which are the doing (e.g. kick, build) and the happening (e.g. rise, melt) which later determines the type of participants included in the clause.

Process Types	Participants
Material (doing, happening)	Actor, Goal, Scope, Client, Recipient
Behavioural (behaving)	Behaver
Mental (perception, affection, cognition, volition)	Senser, Phenomenon
Verbal (saying)	Sayer, Receiver, Verbiage
Relational (attributive, identifying, possessive,	Carrier-Attribute, Token-Value, Possessor-
circumstantial)	Possessed
Existential (existing)	Existent

Table 1. Transitivity Process and Participants (Halliday & Matthiessen, 2014)

Second, the behavioral process occurs between physiological and physiological deeds. Verbs like smiling or dreaming indicate the presence of a senser in the mental process but function as doing (Bartley, 2018). Third, the mental process (e.g. see, feel, think, love, want) applies to our internal experiences, including how we perceive, feel, comprehend, or desire something or someone (Bartley, 2018; Halliday & Matthiessen, 2014). Fourth is the verbal process as in tell, yell, or shout. This process is between mental and relational processes, as saying is not a

solitary act since there is a mental process behind it (Mushtaq et al., 2020). It implies deliberate information transfer to other sources (Bartley, 2018).

Fifth, the relational process deals with the general notions of being, becoming, and having in the way it covers the way symbolic meanings are exchanged (Bartley, 2018; Halliday & Matthiessen, 2014). This method is used to explain the relationship between conventional ideals and their beliefs (Mushtaq et al., 2020). The relational process contributes to the goal of linking two entities (e.g. "She is the new member" [Identifying] or "She is a smart student" [Attributive]) The sixth process only has the Existent that points to a person, an object, an action, an event, an Institution, or an abstraction as existing (Bartley, 2018). For example, "There is a cat on the couch" or "There is a powerful idea."

The transitivity analysis should also cover other than the obligatory participants i.e. the circumstantial element of a clause where more information is added even if it does not affect the whole clause meaning if omitted (Bartley, 2018; Fontaine, 2013). Here, the circumstantial element provides the traditional explanation of when, where, how, and why the thing happens as they fill the position of Adjunct manifested as adverbial groups or prepositional phrases (Halliday & Matthiessen, 2014). Circumstantial elements play a role in establishing meaning are essential parts of the composition and have a mutual influence on each other while the symbolic suggestive structure is unique to its context (Ghazvineh, 2024). These elements serve as an expansion of something else in the form of adverbial and prepositional groups (Fomukong, 2023). Circumstantial factors provide weight to a procedure by providing additional information.

Narrative analysis is the second stage to understanding discursive practice structure. To understand how text elements relate and convey meanings, narrative analysis should be incorporated. It can show how important climate change stakeholders and actors are portrayed as 'hero,' 'villain,' 'helper,' etc. It can also serve to demonstrate how specific storylines form and evolve into master narratives or master frames (Hansen, 2018). Though it is part of the structuralist model, this step is done to show that "the underlying structure is continuously dependent on how it is crystallized in practice that reproduces and transforms it" (Jørgensen & Phillips, 2002). In other words, the practice should be explored to see where the structure originated and what can modify it.

Developing Vladimir Prop's Morphology of Folktales which focuses on narrative roles, Greimas conceptualizes the actantial model which is a theoretical tool employed to evaluate both actual and thematized actions or functions in texts (Hébert, 2020). Greimas points out the actantial elements where a quest is

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pursued in narrative texts and provides three oppositional axes to show the actant's functions on the structure of the narrative (Puckett, 2013). These correspond to binary opposition since finding these conceptual oppositions is the primary responsibility of a textual analyst because it is the way meaning is constructed (Chandler, 2017). Greimas separates the terms of actors, actants, and roles. This step reveals the roles of actors and later defines the actants of discourse that fulfill the three axes. The axis of desire has (1) the subject pursuing the (2) object. The axis of power puts the support to the quest as (3) helper and the hindrance as (4) opponent. The third is the axis of transmission where a (5) sender should deliver the object to the (6) receiver (Schleifer, 2017). The stage to position the actant is to choose the general action, to choose the subject and the object, and to place other actants (Hébert, 2020).

Туре	Sub-types
Extent	Distance, duration, frequency
Location	Place, time
Manner	Means, quality, comparison, degree
Cause	Reason, purpose, behalf
Contingency	Condition, default, concession
Accompaniment	Comitative, additive
Role	Guise, product
Matter	Matter
Angle	Source, viewpoint

Table 2. Circumstantial Elements (Fontaine, 2013)



Figure 1. Greimas Actantial Model (Hébert, 2020)

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The third step is to discuss the issues related to the environment based on the analysis result. The purpose is to employ what Stibbe calls re-minding which is the redressing of erasure and lack of salience from an ecological standpoint (Chau et al., 2022). Here, ecological discourse analysis is used to determine if an ideology encourages individuals to destroy the ecosystem that sustains life or to maintain it even when economic order changes. Salience, erasure, and framing show how an ideology is enacted, characterized as destructive, beneficial, or ambivalent discourse measured by ecosophy (Stibbe, 2021a).

4. Results and Discussion

4.1. Ideational meaning in Joko Widodo's State of the Nation address on 16 August 2022

Transitivity analysis is done thoroughly on the speech text to see the ideational meaning crafted to foster the idea of Indonesia which is directed in the way this speech stands from the viewpoint of current Indonesia. Table 3 below shows the uses of transitivity processes used in the text.

Processes	Material	Mental	Relational	Verbal	Existential	Total
Count	131	12	62	5	2	212
Percentage	61%	7%	29%	2%	1%	100%

Table 3. Transitivity Processes from Joko Widodo's State of The Nation address on 16 August 2022

The material process is found to dominantly appear in the speech clauses 131 times occurrence. Material processes appear to encode actions of a perceived reality. Participants included are actors, goal, scope, client, and recipient, and the circumstantial elements that give additional information on the process taken. The sentences below show the actions that must be performed by the nation to face the challenges.

The challenges (Goal) we (Actor) face (Material P: Doing) today are very challenging, very difficult, and not easy.

The material process is in the verbal group 'face' involving the subject 'we' referring to the addresser and the addressee as the Actor to carry the action to a Goal is 'the challenges.' This sentence appears right after the president salutes the audience. Placing the Goal at the beginning of the sentences invites attention

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to the matter that is problematized from the perspective of the president, and he constructs it as a mutual problem of the entire country.

Health crisis (Goal) due to COVID-19 pandemic (Circ.: Reason) has not been fully (Circ.: Degree) recovered (Material P: Doing) and the global economic situation (Goal) has not been fully (Circ.: Degree) restored (Material P: Doing) either.

Indonesia (Actor) recovers (Material P: Happening) faster (Circ.: Quality), rises (Material P: Happening) stronger (Circ.: Quality).

The two sentences above are part of where the president put the challenges in detail. The first is stated in a passive voice that sounds neutral on the surface. However, by omitting the Actor to the material process carried out in the verbal group 'has not been fully recovered,' it creates a removal of the state authorities that are responsible for the recovery. The speaker also signals that Indonesia's recovery is taking place. By choosing the Material Process of Happening, the speaker perceives that the recovery of Indonesia is just going on without any indicated action that counts for it.

The next process that appears most frequently is the Relational process in 62 times of occurrences. Three types of Relational Processes (Relational P) are found in the speech. First is the Relational Attributive type. Attributes are given to the entities which perceptively suggest the way people rate them. The attribute to challenges, for example here, is described as 'not easy' for the people. It raised the level of difficulty which is already rooted in the word 'challenge' alone.

The challenges (Carrier) are (Relational P: Attributive) not easy for the world and for Indonesia (Attribute).

The second is the Relational Identifying type. It is done with Value attached to a Token. It is done so that a thing is recognized as something else that modifies the sense. The excerpt below shows how Indonesia is valued for the achievement of overcoming the COVID-19 pandemic even with its vast population. There is also a notion of hardship which remains problematic for all countries. Indonesia is identified as 'one of the nations that have overcome the COVID-19 pandemic' and a country that has succeeded in the vaccination program. The sentence implies that Indonesia can overcome adversities. Our country (Token) Indonesia is (Relational P: Identifying) one of the nations that have overcome COVID-19 pandemic, and one of five countries with the highest vaccination rate in the world, with 432 million vaccine doses injected (Value).

Third is the Possessive relational type. The implication of this type is to show what resources that have been owned by the subject as the Possesor. See the

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sentences below where 'we' as Indonesia is attached to the stake of encouraging international collaboration. Expressing the situation in this way lends a sense of optimism to the people.

It (Actor) *indicates* (Material P: Doing) *that we* (Actor/Possesor) *top* (Material P: Happening) *the global leadership and have* (Relational P: Possessive) a *great opportunity to promote international cooperation* (Possessed).

However, it is still worth seeing how Indonesia is shaped in the speech to compare how it is mentioned in the other part of the speech. Indonesia is attributed as a strong nation and identified by the value of overcoming the global crises and being the supplier of lithium battery manufacturers.

Indonesia's economic fundamentals (Carrier) remain (Relational P: Attributive) strong (Attribute), in the midst of global economic turbulence (Circ.: Concession).

To date, Indonesia (Token) has become (Relational P: Identifying) the key producer of lithium battery in global supply chain (Value).

Fourth, when it comes to political speech the use of this process is meant to invite the audiences to internalize the phenomena whether it is done through awareness, reasoning, or appeal with Mental Processes (12 times). This type of process also works to mentally implement the ideas to the audience by altering the perception of a situation.

High trust from the international community (Phenomenon) can be felt (Mental P: Perceptive) in our country (Circ.: Place).

The verbal group 'can be felt' as seen above operates the Perceptive type of Mental Processes. Choosing passive voice omits the Senser. At the same time, it opens the chance to assume that the Phenomenon, filled by the noun group 'High trust from the international community', is perceived together with the citizen as it is completed with the Circumstantial Element providing the Location information that is 'in our country'.

I (Senser) believe (Mental P: Cognitive) that we will become a competitive green product manufacturer in the international trade (Circ.: Matter).

We (Senser) need (Mental P: Desiderative) to build an integrated ecosystem for industry in our country which will support the development of global green economy ecosystem (Phenomenon: Act).

Thus, the nation is lured to being aware of having high international trust, believing in a competitive green product manufacturer, and wanting to support the development of green energy manufacturing.

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The Verbal process [5x] signifies how the speaker consciously expresses his thoughts to others, transcending the inner thoughts. The use of this type of process may accentuate one's standing point that others are expected to agree with. In the speech, the president emphasizes on saying about the nation's great agenda that should be succeeded by the people by being watchful. See the excerpts below:

I (Sayer) reiterate (Verbal P) that we must always remain vigilant, cautious, and alert (Verbiage).

There are at least five big agendas that (Verbiage) I (Sayer) have emphasized (Verbal P) earlier (Circ.: Location).

Existential process [2x] denotes the presence of an entity. The speaker of the speech also insists on the presence of a condition that should be followed by the people that is the downstream manufacturers and industrialization which must be operated in the region of the Republic of Indonesia. In addition, five agendas are firmly restated as prevailing conditions.

There is (Existential P) one condition: the downstreaming and industrialization must be done in our homeland to maximize added value for the sake of national interests (Existent).

There are (Existential P) at least five big agendas (Existent) that I have emphasized earlier.

There is no Behavioral process found in Widodo's speech as he focuses more on the realm of action, and thought, and is represented by the occurrence of the material, mental, relational, verbal, and existential process.

4.2. Actants in the quest for advanced Indonesia

4.2.1 The axis of desire

The axis of desire creates the main object of the speech narrative which is the Advanced Indonesia. The subject is presided to wanting the fulfillment of Advanced Indonesia. The notion of Advanced Indonesia appears in the mental process as an object of desire, a material process of doing and happening as a circumstance that falls in the category of product and purpose. Therefore, Advanced Indonesia fills as the Object actant of the quest. The phrase occurs significantly in the circumstantial element of the clause as Product which means the expected final result of the quest.

On the other hand, we (Actor) must continue (Material P: Doing) with the nation's big agendas (Circ.: Comitative) to achieve (Circ.: Purpose) an Advanced Indonesia (Circ.: Product).

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With such great capitals and opportunities, we have a big chance to develop an inclusive, fair, and sustainable Indonesia (Circ.: Product).

In the axis of desire, the subject takes on the actantial roles that represent the subject as wanting, knowing, and capable, and which thereafter point to the three phases in the subject's development of its modal competence (Greimas & Courtés, 1982). The sender is recognized by any actor who eventually brings about action, belief, will, obligation, knowledge, or power (Bertrand, 2019). Here, subject actants are filled by the participants that put 'we' as the senser of desiderative processes, and 'we', 'us', and 'I' as the actors in the doing and happening.

We (Senser) need (Mental P: Desiderative) to build an integrated ecosystem for industry in our country which will support the development of global green economy ecosystem (Phenomenon: Act).

I (Senser) believe (Mental P: Cognitive) that we will become a competitive green product manufacturer in the international trade (Phenomenon: Act).

Thus, as the subject of the sentence, 'we' is an inclusive pronoun referring to the speaker and the audiences (the people of Indonesia or their representatives), and T' refers to the speaker himself as individual citizen and as a decision maker addressing what the people's needs.

4.2.2 The axis of transmission

The Subject is assigned by a contract which is virtually done with the Sender and produces the axis of transmission (Greimas & Courtés, 1982). As the Indonesian President the contract also happens as the commitment to the national virtues such as The Five Principles of Pancasila, Bhinneka Tunggal Ika (Unity in Diversity), Patriotism, Spirit of Nationalism, Democracy, and National consolidation. They are meant to be the foundation of the programs chosen for Advanced Indonesia. In the axis of transmission, they fill the Sender role.

Noble values, Pancasila (the Five Principles, the Indonesian State Ideology), Bhinneka Tunggal Ika (unity in diversity), and patriotism (Token) are (Relational P: Identifying) the main pillars (Value).

Meanwhile, the Object that is pursued by the Subject will benefit the Receiver. In this case, the repeated saying of Advanced Indonesia roughly implies that the Receiver actant is filled by the country itself as one who will receive the benefit. But it still can also be acceptable if interpreted by knowing that the addressee of

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the speech is the Indonesians as the occasion of celebrating Indonesia's Independence Day may give the context.

A type of circumstantial element to be highlighted here is in the category of Cause which covers the notion of reason, purpose, and behalf. Cause as enhancing circumstantial endow a view of existing conditions leading to the actualization of the process, the consensus of intended condition for the process being actualized, and for whose sake the action is carried out. Cause, as the transitivity test suggests, covers reason (because of what?), purpose (what for?), and behalf (who for?).

There is one condition: the downstreaming and industrialization (Goal) must be done (Material P: Doing) in our homeland (Circ.: Enhancing: Location: Place) to maximize added value (Circ.: Enhancing: Cause: Purpose) for the sake of national interests (Circ.: Enhancing: Cause: Behalf).

The choice of mentioning national interests, our country Indonesia, authorities and responsibilities, and micro, small, and medium enterprises provide a strong persuasive effect to the audience where all the planned actions must be supported as they should be done for the state's common good.

4.2.3 The axis of power

To fulfill the quest, the subject must gain the capability that is enabling and also notice the obstacles that deter or disable the course to reach the desired object. Helper brings its service to allow the functioning of the subject's narrative program (Greimas & Courtés, 1982). Analysis of the text shows that the Helper actants are economy, natural resources, the people, international recognition, industrialization, desirable qualities of the people, and the ongoing assignment of state institutions.

Economy:

Our inflation rate (Carrier) is (Relational P: Attributive) under control (Attribute), in the range of 4.9% (Extent).

Inflation is attributed by adjectival under control creates a positive judgment, while investment growth and trade balance become the actors to happening processes and are also attached with positively connotated words like surplus and increase. This combination shows the speaker's view towards the economic state which is beneficial for the country development. Thus, economy condition supports the quest of Advanced Indonesia.

Natural resources:

The utilization of marine biodiversity (Token) wisely (Circ.: Quality) will become the biggest source for food (Relational P: Identifying), pharmaceutical, and energy products (Value).

Biodiversity in this speech is placed in the relational process at the subject position where they become token and carrier. As token, they are recognized as sources for making food and products for medicine and energy. As carrier, biodiversity is qualified to be prospective support to the Advanced Indonesia.

The People:

Ulemas, religious leaders, and traditional leaders (Actor) actively (Circ.: Quality) assist (Material P: Doing) the communities (Goal).

The people here include ulemas, religious leaders, traditional leaders, people, and socio-religious organizations who become actors contributing to the communities, but no circumstantial element further tells in what way they are aiding. Then, a young productive age is seen as the supports the nation's economic strength only by the purchasing power. In addition, socio-religious organizations are said to help the communities but without mentioning what term their contributions are for. However, by mentioning them, the goal of mentioning the in the speech is to have them feel thanked so that it persuades a cooperative attitude towards Jokowi's vision.

States Institutions:

Health workers, the TNI, and the Polri, as well as ranks of bureaucracy (Actor) synergize (Material P: Happening) and cooperate (Material P: Happening) with each other (Circ.: Comitative).

Ranks of state institutions are mentioned as the actors whose achievements are contributing to the nation's interest. There is no circumstantial element for this mention which describes the area or measurement of which they are working. Again, mentioning them projects a desire for an obliging bearing which works for Advanced Indonesia. This internal support is placed as important as the external support which are the international trust, being assigned by the UN as a member of the Champions of the Global Crisis Response Group and awarded by the International Rice Institute.

International recognition:

The fourth capital (Token) is (Relational P: Identifying) international trust which is increasing exponentially (Value).

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These international recognitions are identified by the speaker as the fourth capital in the making of Advanced Indonesia. They are related to the propensity of Indonesia's capability in facing crises since 2019.

Industrialization:

For instance, downstreaming of nickel industry (Actor) has multiplied (Material P: Doing) export of iron and steel by 18 times (Goal).

Industrialization is conditioned as a national interest by putting them in the Cause type of circumstantial element following a material process of doing. Nickel industry becomes the actor of increasing the export of iron and steel giving it a sensible reason to continue the development of green industrial zone in North Kalimantan.

Quality of the people:

I (Actor) call on (Material P: Doing) all components of the nation (Goal) to unite, to support the big agenda for the achievement of Advanced Indonesia (Circ.: Purpose) with commitment, with hard work, with innovation and creativity (Circ.: Comitative).

Indonesian people are framed to be helpful to the Advanced Indonesia agenda so far as they possess qualities that include being prudent, vigilant, hardworking, innovative, and creative. The predisposition is to relate these merits to Advanced Indonesia which means other than these traits are not accommodating to the vision.

As for the obstacles that are gained from the speech text covers several types of crises that involve public health, global economics, the war of Ukraine and Russia, food shortage, energy supply, poverty, and heated geopolitics. There are also mentions of identity-religious politics and social polarization.

I (Actor) would like to remind (Material P: Doing) everyone (Goal) to avoid identity politics, to avoid religious politics, and to avoid social polarization (Circ: Purpose).

The health crisis and global economic situation are said to not be resolved implying that the consequences of such a situation will cause more situations and challenges to the quest of Advanced Indonesia. Meanwhile, other inescapable threats come from war, famine, food, energy, and financial crises. In addition, the national security is overshadowed by world geopolitics. The speaker wishes the people to stay away from identity-religious politics and social polarization. What is stated as threats and should be avoided makes them fill the actant position of Opponent. The figure below shows all three axes of Greimas's

actantial model that reveal the functions and relationships of entities mentioned in the speech.



Figure 2. Actants in the quest of advanced Indonesia

4.3. Advanced Indonesia as destructive discourse

Indonesian Independence Day celebrated every August 17 is a monumental event as the ceremony has always been awaited by Indonesian citizens annually. Monuments are used by national elites to legitimize the predominance of their political authority and to determine their political goals (Bellentani, 2018). The attention given to the speech delivered on the occasion also invites the interest of linguistic analysis from various perspectives. On the occasion of the 74th Indonesia Independence Day in 2019, the President's speech gained great attention as he announced the relocation of Indonesia's Capital City to East Kalimantan (Siddiq et al., 2021). The speech is found to have a potential for power misuse by having unidentified actors in the agenda through the use of pronouns, nominalization, and passive voice clauses (Max & Zamruddin, 2020). The 77th Indonesia Independence Day speech emphasizes active voices and material processes, highlighting each constituent's contribution to the agendas. This research implies how the speaker prioritizes elements advantageous to their vision of an Advanced Indonesia.

The actantial analysis shows that the agendas to make Advanced Indonesia are supported by economic growth, natural resources, the people, state institutions, international recognition, industrialization, and the quality of the people. They are listed by the speaker as Indonesia's main capital. In terms of ecolinguistics, this speech has performed salience. Salience is where a discourse only emphasizes the area that is worthy of attention (Stibbe, 2021a). Capital cities serve as focal points for societal cooperation, emphasizing key agendas. In this context,

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industrialization gains prominence, with downstream manufacturers playing a significant role in economic growth.

Meanwhile, the trails of nickel mining in the Philippines and Indonesia prove the concurrent evolution of extractive regimes and shifts in the global economy (Camba et al., 2020). From agricultural and plantation land to mining and residential areas, Fatufia village changed environmentally due to modernization and corporate growth that influences social connection and solidarity (Dahlan, 2018). Indigenous rights violations and unsustainable development are major issues in Halmahera, Indonesia, because nickel mining adversely affects indigenous communities, leading to land loss, cultural erosion, and environmental degradation (Nancy, 2022). Additionally, land expansion strategies and infrastructure for environmentally friendly industrial zones in North Kalimantan are facing various obstacles and obstructions that must be overcome (Mamuja & Setiawan, 2023). These studies illustrate that extractive mining is not sustainable or environmentally friendly. The speaker emphasizes the extractive industry and downplays other aspects of life that affect the locals.

The talk about nickel appears after the speaker says "With such great capitals and opportunities, we have a big chance to develop an inclusive, fair, and sustainable Indonesia" (Widodo, 2022). A disturbing framing comes from the word sustainable. Although often used as synonyms, the notions of sustainability and sustainable are disputed for their meaning and applicability to real systems (Ruggerio, 2021). The use of "sustainable" raises the question of whether it benefits the environment or the economy. To keep the economy going, many governments, businesses, and industries 'green' their projects and items to appear durable and environmentally friendly (Barbosa et al., 2014). So, it only offers a false impression of standing on the side of ecology.

Also reframed as Helpers to an Advanced Indonesia are natural resources, population, worldwide recognition, industrialization, desired attributes of the people, and governmental institutions. Indonesia can only develop as the speaker wants by using natural resources intensively in industry. Furthermore, Indonesia's productive youth are praised for their spending power, not their environmental concerns from overconsumption. International recognition validates Jokowi's developmentalism. Nonetheless, prudent, vigilant, hardworking, imaginative, and creative people are expected to assist the national agenda and the bureaucracy and law enforcement. The reframing of the support Jokowi needs to build his vision proves even further the notion of Jokowi's new developmentalism where his pragmatic attempt to modernize Indonesia under the shade of the New-

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Order by conducting a stable state to accelerate 'national development with the state sector as a locomotive for economic growth' (Warburton, 2016).

Besides salience, there is erasure. The term 'erasure' is used in several ways to signify that something significant has been disregarded, sidelined, or eliminated from discourse while it is always partial, combining certain parts while excluding others while representing and structuring social life (Stibbe, 2014). As Opponents or the challenges to the agendas, there are global economics, war between Ukraine and Russia, food shortage, energy supply, poverty, and heated geopolitics. It shows an erasure of ecological problems such as climate change and natural destruction to be recognized as national challenges just by not mentioning them at all. Leiserowitz et al. surveyed that the majority of Indonesians are worried about global warming, deforestation, and forest fire and some perceive that Indonesia is already harmed by it (Leiserowitz et al., 2023). The failure to recognize the challenge of climate change and its effect in the future influences the policies made by the government.

The speech also erases biodiversity conservation. According to the speech, biodiversity is only useful if used, as in "the utilization of marine biodiversity." It provides food, pharmaceuticals, and energy. Indonesia has significant potential in "a vast area with the greatest biodiversity". Utilization conceals the actordriven verb 'utilize'. Here, biodiversity is "affected in the process and not the actors in their own history" (Forte, 2020). Here, the way the speaker perceives biodiversity as a resource reflects the anthropocentric mindset. The erasure of indigenous people's role is riotous in this speech. The only recognition given to the traditional people was when he said "Ulemas, religious leaders, and traditional leaders actively assist the communities" in the context where their action only benefits the nation in directing the community under the government's attempt to eradicate COVID-19. In East Kalimantan, plantation and mining property has cleared forest and changed river course, erasing Dayak territory. The state has yet to decentralize natural resources management to user-groups (Erbaugh, 2019). Erasure is not just a property of discourse or a purposeful act of exclusion and marginalization by the discourse leader. Instead, it is part of a discursive fight to change things by claiming something important was left out.

In addition, the speaker mentioned, "I emphasize that agrarian reforms, social forestry, and land certification must continue" (Widodo, 2022). Social forestry has five operating schemes which are village forests, community forests, community plantation forests, forestry partnerships, and customary forests where land tenure, contract duration, and allowed activities are different one from another (Rakatama & Pandit, 2020). Studies show that political economics

shapes land tenure reasoning and that it and local interests and practices have inadequate and disorderly frictional contacts (McCarthy et al., 2022) especially when it comes to conservational purpose (Handayani et al., 2022). The legal uncertainty surrounding the protection of customary land, a decline in the wellbeing of customary law communities, and inequality and discrimination against indigenous and tribal peoples are all consequences of the problematic protection of customary land rights in customary law communities (Swardhana & Jenvitchuwong, 2023). State policies and their execution by formal institutions may fail to deliver equitable, inclusive, and sustainable results without organized citizen groups working for common good (Sirimorok et al., 2023).

Discursive talks of economics, consumerism, and agribusiness can thus be named horrendous talks, since the ideologies they carry go against the standards of the ecosophy (Stibbe, 2014, 2021b). The discussion above shows that the notion of Advanced Indonesia is a destructive discourse. It is destructive for opposing points of ecosophy. The speech does not value living and does not care about wellbeing for exploiting land through mining and agrarian reform, which impacts living organisms. His restricted development planning for his administration may benefit the present but not the future and does not represent Advanced Indonesia as a destination for future generations to prosper. The discourse narrative's actors do not care enough to reciprocate environmental action, which reinforces the nation's dependence on natural resources. Additionally, it does not encourage environmental limits. Instead, it promotes citizen purchasing to run the economy that undermines social justice. This is because the speech does not allow equal distribution of national resources. Finally, green industrialization promotes catching up with other countries' growth, not resilience from industrialized society's ecological harm.

Previous studies on language and ecology in Indonesia have worked to see the dynamic relationship between humans and nature through various linguistic approaches. Analysis of the lexicon of Mandailing language is found to refer to three classifications of way of working, material, and nature (Dharmawati & Widayati, 2021). A study of Balinese Lexicons of Memande (silver and gold smiths) indicates languages related to human making instruments, ritual and decoration materials, products, and activities (Puspani & Indrawati, 2022). Lexical items of local language influenced by Hokkian and Tio Cu show how cultural assimilation constructs a distinct way to the naming of flora and fauna (Herman et al., 2022). These three studies have documented lexicon but only listed allusions semantically and pragmatically in socio-cultural situations. However, they may help researchers read the human-nature interaction through

language symbols. The research of village names in Nias Regency has shown a close relationship between language, culture, and environmental factors like greenery and mountains, which affect people's spirituality (Hadi & Mulyono, 2023). Ecolinguistic understanding of indigenous people can promote campaigning for linguistic variety and preserving how communities interpret the natural environment, which influences their daily lives.

5. Conclusion

The discourse around an 'Advanced Indonesia' prioritizes economic development and land exploitation, often neglecting environmental considerations. This short-sighted approach lacks reciprocal action toward the environment and fails to address social justice in resource distribution. Green industrialization is perceived as competitive rather than genuinely sustainable. The 2024 Indonesian presidential election outcome, favoring parties aligned with Jokowi's vision, is likely to yield further linguistic phenomena for ecological discourse analysis. This article serves as a methodological reference for future researchers interested in critiquing discourse through an ecolinguistic lens. It is because the way language subsidizes the creation of certain stories or narratives is an important site of examination for ecolinguistics (Wang & Liu, 2024). Examining ideational function has revealed the roles of participants in the discourse and Greimas's actantial model places those participants according to their roles. So, the positioning of ecology in one's ideology can be analytically exposed.

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The representation of nature in a political speech in promoting "Indonesia Maju"

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How can satirical fables offer us a vision for sustainability?

Book Review: Wild Wise Weird, by Quan-Hoang Vuong, AISDL, Hanoi 2024

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Today, with the climate crisis intensifying and planetary boundaries nearly breached, achieving any form of sustainability—whether economic or social—first demands environmental sustainability. Despite the substantial body of research underscoring its importance, a large segment of society remains apathetic and skeptical toward the value of nature and the danger of planetary crises (Norgaard, 2011). Some even go as far as denying scientific evidence or creating false claims about climate change (Harding, 2019). Achieving a fundamental shift in societal thinking—encompassing worldview, values, and beliefs—requires more than just media campaigns, education, and regulatory measures (Abson et al., 2017). The presence of meaningful cultural and artistic works that awaken society is also essential. *Wild Wise Weird* is a typical work, guiding readers to recognize blind spots in their perceptions of the human-nature relationship and helping to restore and revitalize these connections (Vuong, 2024).

Wild Wise Weird by Professor Quan-Hoang Vuong is a social commentary collection featuring 42 fictional fables centering on the character Mr. Kingfisher, who leads readers through diverse stories involving other birds in the bird village. With wit and wisdom, the book offers readers a blend of meaningful social critiques, justifying its title as both "Wild" and "Wise." Unlike most moral books, which deliver straightforward lessons, *Wild Wise Weird* presents readers with the absurdity in human thinking, prompting them to draw their own conclusions about wisdom. Such a "Weird" approach can enable readers to recognize and



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explain unthinkable issues humans are facing, including Jared Diamond's observation that, without external threats, humans may trend toward self-destruction by destroying ecological systems that nurture them (Diamond, 2011).

The absurdity of the human-animal relationship is subtly highlighted in the story "Family Legacy...". The tale begins with large pelicans who, seeming at first like villains due to their excessive, gluttonous fishing, threaten the fishing grounds of Kingfisher for generations. Surprisingly, the pelicans hold a "Certificate of style and ethics in fish catching" and a "Permit to catch fish everywhere," while Kingfisher eventually recognizes that his family and he have fished "illegally" for generations. Though humorous, the story invites us to consider a deeper perspective. When we substitute "pelicans" with "humans" as the culprits, the story offers an authentic perspective from the animals whose habitats—forests, ponds, rivers, and more—are overtaken by humans to do agriculture, industry, mining, and urbanization for their livelihood. Meanwhile, the animals who have lived there for generations become the "illegal" inhabitants, lacking the documentation to prove their right to exist and survive?!

In the final story, "Titles of Nobility," Vuong humorously portrays Kingfisher's excitement upon being awarded two noble titles given by humans: (1) "Bird with high research value, as an ecological indicator" and (2) "Rare bird, requiring priority protection." This honor makes Kingfisher feel exceptional among other birds, only to realize later that these titles are reserved for species facing high extinction risk and qualify for the IUCN Red List. This detail gives readers a laugh at Kingfisher's naive thirst for prestige while prompting reflections on humanity's absurd relationship with nature. Who are humans to bestow "protection-needed" titles on other species? And why has Kingfisher's species declined to the point of needing such protection?

Sometimes, we must find wisdom by confronting foolishness, and it seems that in environmental matters, humanity is doing just that. *Wild Wise Weird* gives ample voice to this truth.

Additionally, *Wild Wise Weird* takes a unique approach compared to most social commentaries aimed at critiquing regimes, societal norms, or ideologies, like *Animal Farm* (Orwell, 1945), *Alice's Adventures in Wonderland* (Carroll, 1865), or *Laugh or Lament* (Nesin, 2002). *Wild Wise Weird* focuses on individual information processing, making it ideologically independent and socially and culturally transcendent. For instance, the dialogue between Kingfisher and Paddy Youth clearly reflects universal insights regarding the diversity in human thinking when approaching the same issue:

"Curious and puzzled, Kingfisher asks:

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- In the same field, how can the two sides be so different? The guys over there are dead serious, while you guys are cheery and breezy.

One Paddy Youth, still dancing to the wind, swiftly replies:

- Sir, it's because our circumstances are different. Our bunch is light and free, while those guys spend all day long worried and guarding their ripe grains. What a terrible waste of time! Beautiful sunny days are for singing, dancing, and chattering away..."

In "Light and Free"; Wild Wise Weird (2024)



Figure 1. "Hot" by artist Bùi Quang Khiêm, from story "No-fish Dietary." Retrieved from *Wild Wise Weird* with the author's permission.

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In fact, the dialogue inspired a study on the intricate interplay between perceived benefits of aquatic ecosystems, knowledge, and emotions about climate change in shaping support for marine protection among stakeholders from 42 countries, primarily high-income nations (Nguyen, Duong, Nguyen, La, & Hoang, 2024).

This independence enables the book's messages to cross socio-cultural boundaries more easily, which is crucial for environmental issues that require both global consensus and local cooperation. Although climate change literature has surged in English-language publishing since the mid-2000s, Schneider-Mayerson (2018)'s survey of readers of 19 climate fiction novels reveals that while these works effectively reinforce the urgency of human-caused climate change among concerned liberals and leftists, they have limited success in persuading skeptics and deniers to reconsider their views.

Moreover, most climate fiction messages cause readers to associate climate change with intensely negative emotions, such as the "doomsday scenario" and "dystopian" (Schneider-Mayerson, 2018). These emotions could result in climate "doomerism," which could depress and demoralize the public and further lead to climate inaction (Campbell, 2022; Ritchie, 2024). Although Wild Wise Weird is also climate fiction and even has a story called eco-horror fiction (i.e., the "Ghosts" story), it reminds readers of failures and predictions of climate and environmental destruction crises' consequences through brain-twisting, symbolic, and humorous fashion. For example, when illustrating the inaction and the superficial, performative efforts of governments and corporations, satirical language was creatively employed:

"*Grand conclusion: The report is still completely honest, trustworthy, and ethical, even though the data are fabricated, and measurements are falsified. The methane emission reduction campaign has achieved phenomenal success. Therefore, the bird village approves the inclusion of the report in Kingfisher's lifetime achievement archive."

In "GHG Emissions"; Wild Wise Weird (2024)

Wild Wise Weird illustrates that conveying environmental messages does not necessarily require strong slogans, radical activism, or vandalism but can instead engage readers through the rationality and emotions of a personified protagonist like Kingfisher (Vuong, Nguyen, Duong, & La, 2024). The character's humor and wisdom invite readers to embrace it, encouraging them to reconsider their own thoughts, choices, and actions to reduce environmental impacts and contribute to ecological sustainability. When blended with natural knowledge (e.g., nesting habits of kingfishers, sparrows, and flowerpeckers in the "Mansions" story or the impressive physical attributes and eating habits of kingfishers in "Miracle") and beautiful pictures, this way of communicating can effectively serve as a memorable way of engaging and educating children about

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our planet's inhabitants. Affinity for these characters can stimulate imagination and engagement with environmental information, helping children—especially those born in urban areas with limited opportunities for interaction with nature—develop an awareness of nature's value (Paulsen, Jagodzinski, & Hawke, 2022; Reason & Gillespie, 2023; Vuong & Nguyen, 2024). This is an ideal starting point for building an eco-surplus culture in society (Nguyen & Jones, 2022).

With wit, wisdom, and a "weird" approach through absurdity, *Wild Wise Weird* fosters readers' awareness, self-reflection, informational connectivity, and even inspires them to confront stupidity to uncover wisdom. This book has the potential to resonate with readers, especially younger ones, embedding ecological sustainability in their humanistic values through the humor, vibrancy, and absurdity of its bird characters, as well as the wisdom woven throughout.

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A vision for just and fair transitions toward a carbon-free world

Review of *A just transition for all: Workers and communities for a carbon-free future* by J. Mijin Cha (2024) MIT Press

Thi-Huong Pham, Manh-Tung Ho

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As time passes, news about the now hotter Earth buzzes through the bird village. Those kingfishers residing along the banks of the Red River often report drying riverbeds and skinny fish. As Kingfisher casts his gaze upon the events that have unfolded, he can't help but feel a sense of unease creeping up within him. He decides to collect all the scientific information concerning climate change and greenhouse gas emissions. An elite squad with a unique talent for gathering vital information is formed for emergency information collection.

In GHG emissions, Wild Wise Weird: The Kingfisher Story Collection, Vuong (2025)

In the latest turn of even, the Trump 2.0 administration had decided to prevent the US delegation to attend the United Nations' Intergovernmental Panel on Climate Change in Hangzhou, China on the first week of March 2025. This move follows the complete and immediate withdrawal from the Paris Agreement on climate change in early 2025 (Schonhardt et al., 2025). The fight against climate change demands a global effort to move away from traditional fuel sources while meeting rising energy needs. But can we innovate and implement new technologies fast enough? Can we balance decarbonization with economic growth? And can we truly imagine a radically different future? Can we even begin to create a shared vision for a future without carbon-emitting sources? How would the classical thinkers and philosophers view our situation?



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Technological visionaries often paint a future powered by clean energy, yet these optimistic visions tend to overlook the messy socio-political realities of such transitions. As *A just transition for all: Workers and communities for a carbon-free future* (MIT Press) powerfully illustrates, there is a vast difference between a so-called 'just' transition and one that is genuinely just. This book offers a much-needed, thought-provoking, and meticulously documented exploration of how political and business leaders can ensure fairness for all stakeholders - especially vulnerable workers and their communities - as the world shifts toward a carbon-free future.

Climate justice: ending fossil fuels equitably

J. Mijin Cha, a faculty member of the Department of Environmental Studies at the University of California, Santa Cruz and a fellow of Cornell University's Worker Institute and the Labor Network for Sustainability, specializes in research on climate and environmental justice, just transition, and labor/climate coalitions (Cha & Grubert, 2025; Pastor et al., 2024; Price et al., 2024). In her latest book, *A just transition for all*, she offers a fresh perspective on 'effective climate advocacy' - how to transition toward a decarbonized economy in a way that protects workers and communities, labor/climate alliances, and the relationship between inequality and the climate crisis. J. Mijin Cha has explored the social causes of climate problems and presents a deep understanding of human environmental rights. Drawing from decades of field research and advocating experiences (Cha & Pastor, 2022), Cha examines the economic and social impacts of transitioning away from fossil fuels on workers and communities. She argues forcefully for justice in this transition, ensuring that all affected stakeholders are protected.

Central to her thesis in the book is the idea that a just transition requires not only *the near-total elimination of fossil fuel use* but also fairness and equity in the process. While this concept is not new, Cha emphasizes the complexity of decarbonizing the economy, particularly in communities across the U.S. and Germany's Ruhr region. The transition, she asserts, is a radical and transformative process that extends beyond reducing greenhouse gas emissions - it necessitates the restructuring of socio-economic and governance systems that have long depended on extractive practices. It must include two principles:

"(1) there must be an actual transition away from fossil fuels, which requires a decline in fossil fuel use, and (2) it must be just - that is, even if the meaning may not be uniform or consistent, justice requires a shift from extractive economies to regenerative ones" (Cha, 2024, p.27).

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Here, Mijin Cha critically examines the long-standing "jobs vs. environment" debate, highlighting its toxic legacy as this argument had been often deployed to delay the process of decarbonization. She documents Tony Mazzocchi's fights since 1993 to secure a "Superfund for Workers," which later evolved into the Just Transition Alliance's six principles: *worker and community leadership; no worker or community left behind, a healthy and sustainable environment, equitable burden and benefits, sustainable economic models,* and *accountability and transparency.* Cha stresses the importance of empowering marginalized communities and workers with the right to challenge any entities (governments, corporations, the military, etc.) that commit economic and/or environmental injustice. And the sixth principle of accountability has percolated into the continued labor-climate alliance, marked by the 2018 People's Climate Movement's main demand being 'climate, jobs, and justice' (p.32).

Here, citing the seminal conceptual review of just transition by Wang and Lo (2021), Cha shows the growing alliance between labor and climate movements makes perfect sense when we recognize science, technology, and society as an interconnected *technosocial system*, highlighting the interdisciplinary nature of justice. The book then introduces with justice concepts, outlining procedural justice (fair participation in decision-making), recognition justice (acknowledging marginalized groups), restorative justice (repairing harm), and distributive justice (fair allocation of benefits and burdens) (Chapter 2, p.34-35). All these types of justice should be in the front of the mind of those fighting for justice in decarbonizing our economy. A key strength of the book is its ability to blend historical and contemporary examples, reinforcing the argument that fossil fuels' deep entrenchment in the socio-political economy has obscured discussions on achieving net-zero emissions .

A vision for regenerative economy: Abandoning extractive and exploitative practices

The key issue, according to Cha, is the exploitative nature of these extractive practices. A truly just world must eliminate the need for unsustainable resource extraction, ensuring that communities do not suffer the same neglect they faced after deindustrialization. Here she introduces the vision of *a regenerative economy*: An economy where resources are regenerated, governance is based on deep democracy, purpose is formed around ecological and social well-being, world view is driven by attitude of care and sacredness, and work is characterized by cooperation. Here, Cha's vision is even more positive and ambitious than most proponents of the green growth approach or green machines approach, which is often criticized for blind faith in how "green" technologies are neutral politically, presumed to be solutions for all problems (Roos & Hornborg, 2024).

Contrary to this dreamlike vision of a new economy, the first chapter shows Cha's realistic understanding of how fossil fuels have shaped a vast *networked* world, where any transition away from traditional energy sources will have widespread, *non-linear effects*. Workers and local communities are particularly vulnerable to these changes, making it clear that moving away from fossil fuels is not just an economic shift but a deeply socio-political and cultural one. The authors show political interventions have facilitated the dominance of fossil fuels, which in turn serve as geopolitical tools for nations to assert power and influence. The continued weaponization of climate change agendas into political tools, driven by ambitions unrelated to environmental concerns has led to antagonism, disputes, and prolonged confrontations among political actors, hindering global efforts to address climate change (Vuong et al., 2024), even at the level of creating a shared vision.

As documented by Cha (2024), fossil fuels have thus expanded their roles beyond energy production to encompass economic, social, and political functions. How do we even begin to embrace a coordinated, science-based approach to build a culture valuing eco-surplus (Ho & Nguyen, 2023; Vuong, 2021; Vuong & Ho, 2024), ensuring effective climate mitigation and adaptation remains a tough question. As such, Cha stresses that a just transition requires active government intervention, including financial support and policies that protect those most affected by the shift, and other critical facilitating conditions as detailed in the four pillars.

The four pillars of a just transition

Cha identifies four essential pillars for a just transition, based on her data and analysis: (1) strong governmental support, (2) dedicated funding streams, (3) economic diversification, and (4) strong and diverse coalitions (Figure 1). Without these foundational elements, any transition risks perpetuating existing inequalities rather than addressing them. She argues that while the challenge of decarbonization is immense, it is also an opportunity to build a more just and sustainable future - one where the benefits of a green economy are shared equitably among all.

The role of the first pillar - the public sector - is to provide policies and legal guidelines. The second pillar ensures strong financial resources to implement a just transition. The third pillar creates job opportunities for workers in industries undergoing transition or decline. The fourth pillar functions as a form of political alliance among individuals and community organizations, enabling proactive action and timely protection of workers' rights. These alliances are crucial in shaping transition policies that accurately reflect the needs of workers and communities while building the necessary political strength to drive policy adoption.



Figure 1. Cha (2024)'s model of regenerative economy (Redistributed under the license Creative Commons Attribution-NonCommercial-NoDerivatives 4.0).

However, the author emphasizes that these four pillars are theoretical guidelines. To effectively implement a just transition, social objectives must be strongly integrated into climate policies.

Past, present, and future of just transition

To provide a clearer picture of how these four pillars operate, Chapter 4 uses the lense afforded by the Four Pillars and analyzes two major transitions in U.S. history: the transformation of the tobacco industry and the Trade Adjustment

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Act. The four-pillar framework offers valuable insights, particularly emphasizing the crucial role of the public sector as the ultimate employer in maintaining equity.



Figure 2. Illustration of four pillars of just transition postulated by J. Minji Cha (2024) by the authors

For instance, through key legislative measures, a stable market was secured for farmers amid the contraction and increased competition in the tobacco industry. Similarly, the Trade Adjustment Act was enacted to balance free trade policies by providing compensation for workers who lost their jobs and for communities indirectly affected by the shrinking labor market. These cases demonstrate that government support significantly impacts the well-being of workers receiving assistance during a transition.

Through the analysis of these two historical transitions, the author concludes that the extent to which the four-pillar framework is implemented directly determines the effectiveness of labor support and just transition outcomes. Therefore, applying these four pillars rigorously is an essential tool for ensuring a just transition away from fossil fuels for workers and communities.

Chapter 5 focuses on analyzing and comparing two key legislative measures: the Inflation Reduction Act (IRA) and the Build Public Renewables Act (BPRA) of New York using the four-pillar framework to assess their ability to promote a just transition. The chapter highlights philosophical differences in transition

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approaches between the two laws and how these differences may impact the fairness and effectiveness of the energy transition.

The IRA follows a market-regulated approach, emphasizing financial incentives for renewable energy production and consumption. It provides tax benefits for corporations to reduce fossil fuel usage. The BPRA, on the other hand, prioritizes the public sector's role in building and managing renewable energy infrastructure, placing a stronger focus on workers' rights.

The author's stance is in favor of the BPRA, arguing that: "The BPRA, in contrast, is building toward a different model for renewable energy development and more aggressively accelerates a transition away from fossil fuels, which, in turn, can more successfully advance a just transition." (p.116). Thus, the BPRA is seen as a more effective framework for a just transition compared to the IRA.

The conclusion of Chapter 5 raises the issue of the necessity for substantial political power to drive climate policies, with the solution found in Chapter 6—promoting alliances and building power from the grassroots as the foundation for a just transition. Focusing on four U.S. states—California, Kentucky, Louisiana, and New York—the chapter analyzes the similarities and differences in their climate struggles, examines their dependence on fossil fuels, and assesses their efforts toward a just transition. For example, the Public Power New York (PPNY) coalition, made up of environmental justice groups and eco-socialists, advocates for shifting control from private utilities to publicly owned renewable energy. They support legislation like the BPRA to expand clean energy and create unionized green jobs (Chapter 5, p.112).

From this, the author highlights the importance of organizing and forming alliances, building power to drive change at local, state, and federal levels, and the political and policy aspects of the just transition process.

Continuing the fight

The book drives home the point that what matters most is the *community-based, community-led organizing* and the *creation of strong, diverse alliances* to fight for just transition. This view underlines the cooperation character of the vision of a regenerative economy. Hence, the alliances can then unify around a common vision for a just transition, build power, and deploy it through various strategies to advance the transition process. A just transition requires a comprehensive transformation - not just of energy sources but also of institutions, political and social structures.

The vision for just transition in Cha's work is among many visions for sustainability that have been proposed and continued to garnered attention and supports and evaluations in the world where human-machines interaction are

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increasingly changing human-nature interactions (Ho & Vuong, 2024). For example, the eco-socialists proposed a transformative political philosophy that integrates ecological principles with socialist economics, asserting that capitalism's profit-driven nature is fundamentally incompatible with environmental sustainability and social justice, instead advocating for democratic ecological planning, collective ownership of productive resources, and prioritization of use-value over exchange-value in a society where ecological limits are respected and human development flourishes beyond material accumulation (Albert, 2023). Or Quan-Hoang Vuong's semiconducting principle of monetary and environmental values offers another alternative to standard economics, but with notable differences from Cha's approach. The key feature of Vuong's principle is its unidirectional conversion property: "the environmental value can be accounted for as a monetary one, but NOT vice versa" (Vuong, 2021). This asymmetric relationship creates a one-way valve that prevents the substitution of environmental value with mere monetary compensation. Vuong's principle focuses more explicitly on reforming business culture and profit calculations. These visions provide policymakers, workers, businesses, and other stakeholders with rich foods for thoughts, thus, potentially lead to further productive adaptation of strategies for better climate advocacy.

In summary, A Just Transition for All: Workers and Communities for a Carbon-Free Future focuses on the concept of 'Just Transition' within the context of energy transformation. Through the Four+ Pillars framework and grounded, empirical research, Cha provides a roadmap for actualizing just transition in the U.S. context. It explores the gap between theory and practice through interviews with policymakers and affected communities facing the decline of the fossil fuel industry. The book underscores the importance of building strong and diverse alliances and the role of politics in achieving fairer policies. Additionally, it examines the multidimensional nature of the transition, where extractive industries extend beyond economic factors to cultural and social dimensions. Ultimately, the book argues that a just transition must address people's material needs, redistribute resources, and create a more just future for all. The vision presented in the book is one of humanity's future development—perhaps it is time to acknowledge and embark on a new revolutionary, humane transition that ensures social justice and ecological balance.

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