UBT

Race To Zero
Strategic Plan24-25

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CONTENTS.

UBT Commitment to Sustainability

UBT is committed to integrating sustainability into all aspects of university life. We aim to minimize our environmental impact, reduce carbon emissions, and empower our community with the knowledge and skills to drive positive change. By aligning with the UN Sustainable Development Goals and KSA Vision 2030, we will foster a culture of sustainability through education, innovative projects, and collaboration, working towards carbon neutrality.

I. MESSAGE FROM LEADERSHIP

At UBT, we recognize the critical role we play in addressing climate change. By joining the global "Race to Zero," we commit to halving our emissions by 2030 and achieving net-zero carbon by 2050. This commitment is more than an environmental initiative—it is a pledge to ensure a sustainable and prosperous future for Saudi Arabia and the world.

Aligned with KSA Vision 2030, our efforts to meet the Sustainable Development Goals (SDGs) are crucial. Climate action is central to fostering innovation, driving economic growth, and protecting our environment. As an educational institution, we are uniquely positioned to lead by example, empowering the next generation to tackle these global challenges with innovative solutions.

Our journey toward carbon neutrality involves bold changes at every level. We are transforming our campus infrastructure, adopting clean energy, and promoting sustainable transportation and procurement practices. Initiatives such as tree planting and will also help offset our carbon footprint.

This endeavor requires the commitment of every member of our community—students, faculty, staff, and partners. Together, we are not just following global sustainability trends; we are leading the charge for a better future, for our region and beyond.

Thank you for being part of this vital journey.

Weam Tunsi ,

President Of UBT

II. INTRODUCTION

UBT proudly announces its Vision for Sustainable UBT 24/25, which aligns with the worldwide effort to tackle climate change. This action plan aims to increase our university's efforts to incorporate sustainability across the community, including students, teachers, staff, and external partners. In addition to our collaboration on the Race to Zero initiative. This effort demonstrates our commitment to reaching net zero carbon emissions by 2030.

Our goal is to incorporate sustainability concepts, such as economic viability, environmental stewardship, and social responsibility, into all aspects of university life, from instruction and research to community participation. By participating in the Race to Zero, UBT demonstrates its commitment to developing strong carbon reduction measures that line with global objectives, fighting for a future that prioritizes environmental integrity.

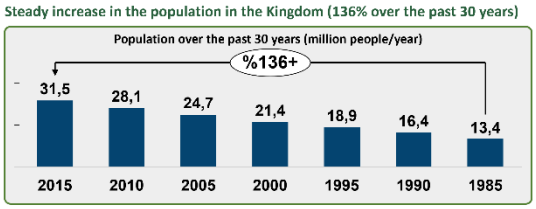
As part of This initiative, the UBT Sustainability Committee, is devoted to building a sustainable culture by incorporating environmental awareness into all operations. Our objective is to empower the UBT community via targeted training, promote creative projects, advance sustainability-focused research, and collaborate with local and international partners.

Through this strategy, UBT aims to build a sustainable, resilient, and inclusive campus that represents our commitment to a brighter future for everyone. Together, we can inspire change, develop solutions, and drive collective action towards a more sustainable future. UBT has set long-term goals to lower its environmental footprint and promote sustainability throughout its activities. These objectives include creating a carbon-neutral and zero-waste campus, a Gold Sustainability certification under the STARS® system by 2030, and zero carbon emissions.

III. DRIVING FORCES FOR CLIMATE ACTION

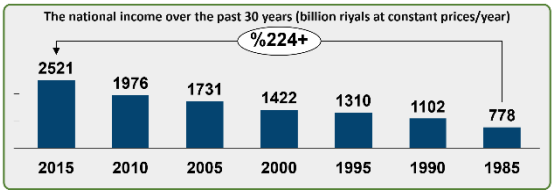
A Blend of the global Sustainable Development Goals (SDGs) with the national factors influenced by KSA Vision 2030.

1. Population Growth and Urbanization



- The substantial increase in population in KSA over the past 30 years has intensified the demand for resources, infrastructure, and urban development.
- SDG 11 (Sustainable Cities and Communities) is directly relevant here, emphasizing the need for inclusive, safe, resilient, and sustainable urban areas to accommodate the growing population.

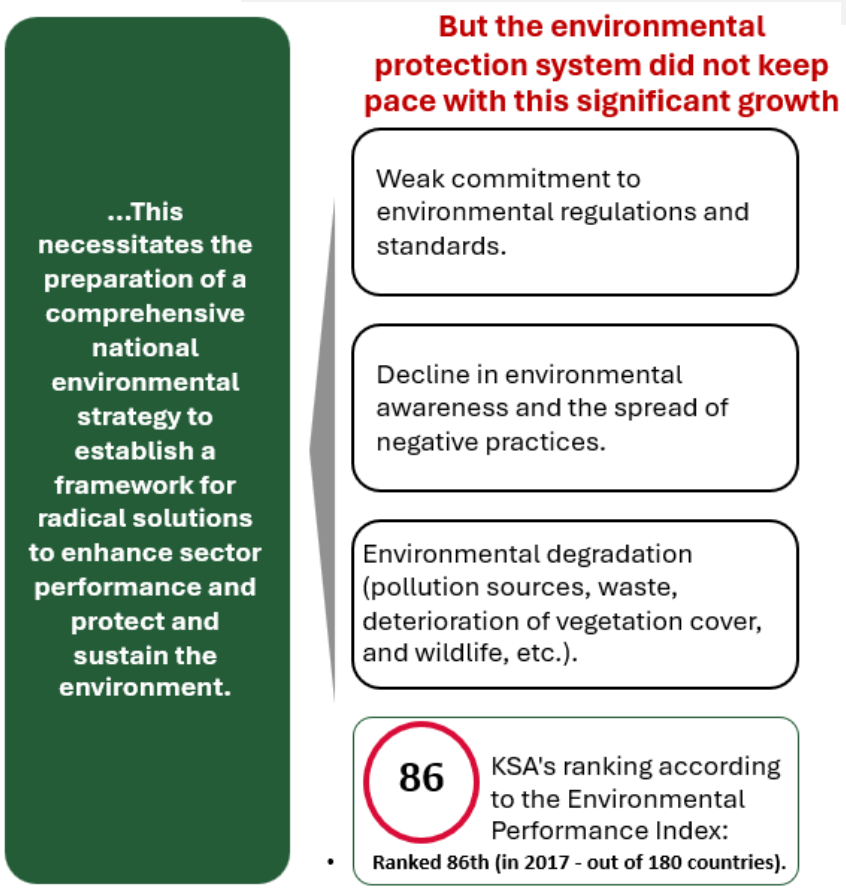
2. Economic Development and Diversification



- KSA's focus on growing key sectors like energy, industry, agriculture, transportation, and mining has increased pressure on the environment.
- To align with SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation, and Infrastructure), KSA aims to promote sustainable economic growth while reducing environmental impacts through innovative and eco-friendly technologies.

3. Climate Change and Environmental Degradation

- The region faces significant environmental challenges such as desertification, declining air and water quality, loss of biodiversity, and increased carbon emissions.
- SDG 13 (Climate Action) and SDG 15 (Life on Land) are crucial in addressing these issues by adopting strategies for climate resilience, reducing emissions, and protecting ecosystems.



4. **Waste Management and Sustainable Consumption**
    - The increase in waste generation from urban and industrial activities necessitates effective waste management and recycling initiatives.
    - SDG 12 (Responsible Consumption and Production) supports KSA's objective to reduce waste, promote recycling, and encourage more sustainable consumption patterns.

5. **Improving Environmental Performance and Biodiversity Conservation**
    - The need to enhance KSA's Environmental Performance Index (EPI) ranking, and address biodiversity loss is a significant factor in its sustainability strategy.

- **Summary**

Climate change , and particularly as the release of greenhouse gases (GHG) continues to rise and intensify global climate challenges is one of the most urgent global challenges today, with clear scientific consensus that human activities, including industrialization, energy consumption, and deforestation, are the primary contributors The effects of climate change are already evident, manifesting in severe consequences such as increased health risks from extreme weather events, loss of biodiversity, heightened occurrences of wildfires, floods, and droughts, and growing concerns over food security. The Intergovernmental Panel on Climate Change (IPCC) reports that greenhouse gas emissions have been the leading cause of global warming since the mid-20th century, underscoring the critical need for collective climate action at every level of society. In Saudi Arabia, the drive for sustainability is shaped by **both national priorities and global responsibilities**. The nation's rapid economic growth, rising population, and environmental challenges demand a focused approach to sustainability. By aligning with the UN Sustainable Development Goals and Vision 2030, Saudi Arabia seeks to balance its economic ambitions with environmental preservation. As an institution committed to shaping the future, UBT understands its pivotal role in fostering a culture of climate action and environmental responsibility among students, faculty, staff, and the broader community, this strategy emphasizes clean energy promotion, efficient resource management, waste reduction, and climate resilience while fostering partnerships for sustainable progress.

The alignment of global climate goals **with Saudi Arabia's Vision 2030** allows UBT to take a leadership role in regional sustainability efforts, integrating these principles into its operations and driving positive climate action.

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IV. Goals and Objectives of plan

Vision of Sustainable UBT

Creating an action plan to strengthen the university's efforts to spread the concept of sustainability throughout the university community, as well as incorporating the concept of sustainability in its broadest sense into all of the university's practices, strategies, projects, and principles, and reflecting this in terms of education, research, and student activities.

Mission of Sustainable UBT

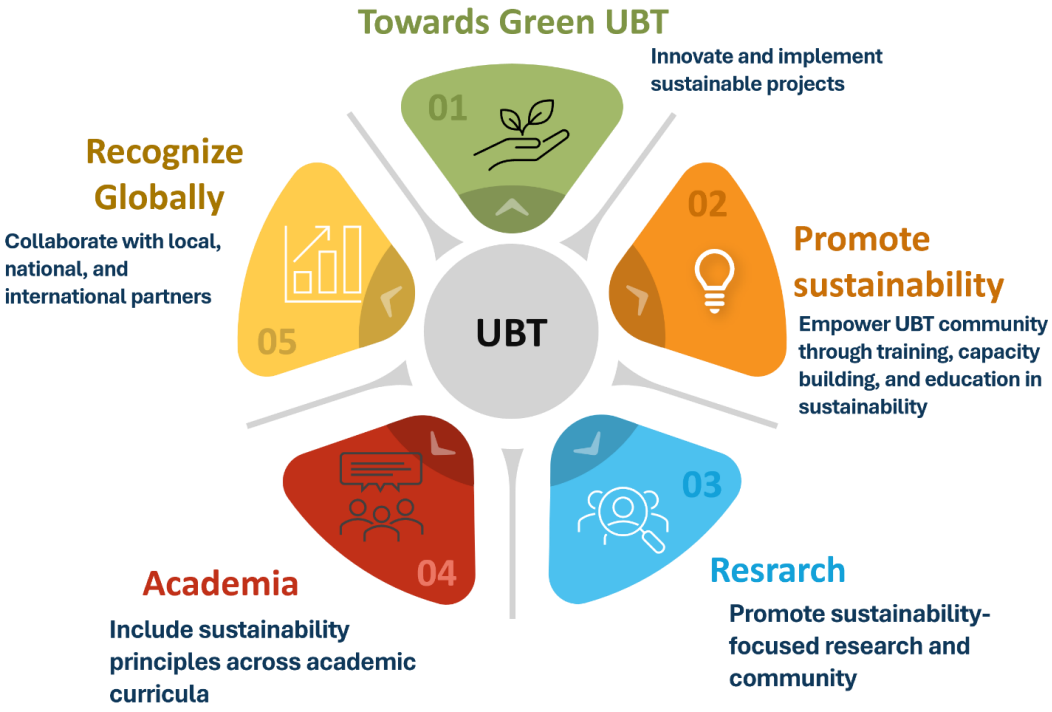
The UBT Sustainability Committee is committed to fostering a culture of sustainability by integrating environmental awareness, social responsibility, and economic viability into all aspects of university life.

We aim to:

1. Empower UBT community through training, capacity building, and education in sustainability.
2. Innovate and implement sustainable projects and operations that minimize our environmental impact.
3. Promote sustainability-focused research and community service that addresses local and global challenges.
4. Embed sustainability principles across academic curricula, ensuring that every graduate is equipped with the skills and knowledge to contribute to a sustainable future.
5. Collaborate with local, national, and international partners to drive collective action and achieve shared sustainability goals.

Sustainable UBT Strategic Goals

The UBT sustainability committee continues supporting UBT commitment and action towards climate change and sustainability. A set of strategic goals and objectives are highlighted below:



Sustainability Dimensions:

The sustainability action plan of UBT is designed to accomplish the sustainability strategic goals by focusing on specific actions and procedures that encompass six primary dimensions, as depicted in the following diagram:

1- Sustainability awareness and training
2- Projects & operation
3- Research &innovation.
4- Academia & education
5- Partnerships & Outreach
6-

V. Sustainable UBT Action Plan

Through the coming proposed actions, we strive to create a sustainable, resilient, and inclusive campus that reflects our commitment to a better world for all.

Objective 1: Increase Awareness of Sustainability Practices

Proposed actions:

- Host sustainability awareness workshops for students and staff, covering key topics like SDGs, energy saving and waste reduction.
- Implement specialized training programs for campus staff on energy efficiency and green building maintenance.

Objective 2: Engage UBT Community in Sustainability Efforts

Proposed actions:

- Launch a "Green Campus Day" involving the whole university community in sustainability-focused activities like recycling drives and tree planting.
- Organize community outreach programs where students and staff engage with local schools to promote environmental awareness.
- Engage a campus-wide volunteer network that regularly participates in environmental initiatives, such as beach clean-ups.
- Establish a car polling program/ application for students and staff to promote eco-friendly transportation.
- Promote campaign to decrease the usage of one-use plastic bottles, create sustainable flasks for students and staff to be shared as give away.

Objective 3: Increase visibility for sustainability issues.

Proposed actions:

- Create sustainability infographics and posters to display around campus, focusing on issues like awareness about SDG, plastic waste and water conservation.
- Use social media and newsletters to regularly highlight sustainability milestones and upcoming green events.
- Hold sustainability hackathon for students/ staff to create solutions and ideas towards certain sustainability challenges.
- Promote campaign for measuring environmental footprint to students and staff and help them to reduce their environmental footprint.

objective 1: Ensure Sustainability in Campus Operations

Proposed actions:

- Conduct a comprehensive energy audit of campus facilities and implement efficiency measures by installing occupancy sensors. This can be done in a pilot area, then repeated.
- Decrease water flow rate by installing water saving filters to
- Install leak detection system so that leaks can be addressed quickly and efficiently.
- Implement Building management system BMS to optimize energy efficiency.
- Make cleaning plan to All Washbasin Taps & Bib-Taps (should be cleaned once a month or once a quarter)
- Install water-saving devices like low-flow faucets and toilets in all university facilities.

Objective 2: Promote Sustainable projects.

Proposed actions:

- Introduce a green procurement policy that prioritizes eco-friendly and sustainable products.
- Develop a campuswide recycling program by implementing comprehensive recycling, and waste reduction initiatives.
- Set up electronic waste recycling drives to safely dispose of old electronics and raise awareness about e-waste issues.
- Establish a food waste reduction program in campus cafeterias, promoting sustainable dining and composting.
- Coordinate with Sustainability Awareness & Training team to prepare awareness campaign on waste reduction and recycling.
- Develop sustainable planting strategy that use sustainable irrigation system, reused water and native vegetation.

Objective 1: Promote Sustainability-Focused Research

Proposed actions:

- Offer sustainability research grants for faculty and students, particularly projects focused on renewable energy and resource conservation.
- Establish a sustainability research center that promotes interdisciplinary research and collaboration on environmental issues.
- Create an annual sustainability innovation competition, encouraging students to develop new solutions for environmental challenges.

Objective 2: Support Student Research

Proposed actions:

- Create a research fellowship program for students focused on sustainability topics, offering mentorship and funding.
- Partner with local businesses and industries to provide research internships that focus on sustainable solutions.
- Offer opportunities for students to present their sustainability research at national and international conferences.

SUSTAINABLE DEVELOPMENT GOALS	UBT Articles Relevant to or have impact on SDG (No.)
G1. No Poverty	1
G2. Zero Hunger	1
G3. Good Health and Well-being	16
G4. Quality Education	7
G5. Gender Equality	10
G6. Clean Water and Sanitation	1
G7. Affordable and Clean Energy	13
G8. Decent Work and Economic Growth	13
G9. Industry, Innovation, & Infrastructure	31
G10. Reduced Inequality	11
G 11. Sustainable Cities & Communities	18
G12. Responsible Consumption & Production	12
G13. Climate Action	12
G14. Life Below Water	1
G15.Life on Land	6
G16. Peace & Justice Strong Institutions	9
G17. Partnerships to achieve the Goal	6

Objective 1: Embed Sustainability into the Curriculum

Proposed actions:

- Work with department heads to integrate sustainability concepts into core courses across all disciplines.
- Introduce project-based learning modules where students solve real-world sustainability challenges (real world challenge).
- Encourage course leaders to adopt sustainability approaches in students' work and projects.
- Map the course specification with sustainable development goals SDGs.
- Integrate sustainability into capstone projects, allowing students to address real-world environmental problems.

Objective 2: Promote Interdisciplinary Learning in Sustainability

Proposed actions:

- Develop a sustainability course that is offered to all UBT programs and offer it from interdisciplinary perspective.
- Establish a new program (undergraduate or postgraduate) that combines sustainability with majors like engineering, business, or public policy.
- Offer sustainability-themed study abroad programs or workshops where students can learn about global environmental challenges.

Objective3: Collaborate on Global Sustainability Solutions

Proposed actions:

- Join international sustainability networks to share best practices and collaborate on global sustainability challenges.
- Partner with universities worldwide to create joint sustainability research projects and exchange programs.
- Encourage faculty to participate in sustainability-themed conferences that bring together international experts, students, and faculty.

5- Partnerships & Outreach

Objective 1: Build Partnerships for Sustainability

Proposed actions:

- Establish collaborations with local businesses and government agencies on joint sustainability initiatives, such as renewable energy installations.
- Partner with local NGOs and community organizations to work on sustainability outreach and education programs.
- Develop industry partnerships that provide students with internships and job placements focused on sustainability.
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Objective 2: Engage the Community in Sustainability

Proposed actions:

- Partner with local organizations to create hands-on sustainability projects, such as urban gardens or renewable energy installations.
- Develop a student-led environmental education program to teach sustainability practices to the local community.
- Organize sustainability service-learning opportunities, where students apply sustainability concepts through community projects.
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Actions taken:

UBT in Collaboration with its partners (Ahlia University) have successfully launched an open access academic journal published by Emerald referred to as "Journal of Business and Socio-Economic Development". The journal aims to publishes peer-reviewed research that highlights business problems faced by modern-day institutions and provides practical and sustainable solutions to improve them. The journal aims to prescribe and improve business theories and
practices and to encourage scientific research into sustainable governance and
business ethics

VI. PLANNING TIMELINE

September 2024

Draft Phase

The initial phase focuses on developing a comprehensive climate strategy for the entire university. to achieve Carbon Neutrality by 2040 and Zero Carbon by 2060.

November 2024

Assessment Phase

This phase involves a detailed assessment of the university's carbon footprint, focusing on direct emissions.

March 2025

Planning Phase: Scope 1 Plan

The focus shifts to developing and implementing strategies to reduce direct emissions based on the audit results.

November 2026

Scope 2 & 3 Audit

The carbon footprint analysis expands to include indirect emissions, like purchased electricity and transportation.

March 2026

Climate Action Plan for Scope 2 & 3 Emissions*

- Initiate further strategies for reducing indirect greenhouse gas emissions, in alignment with the findings from Phase 4.

September 2026

Implementation Phase:

Begin implementing all planned initiatives to gradually reduce the overall carbon footprint of the university in a phased manner, ensuring close monitoring and adjustment of strategies for efficiency.

VII. Carbon Emissions Action Plan

A. Carbon Footprint Calculation

1. **Define Emission Scopes:** Identify and categorize emissions into Scope 1, Scope 2, and Scope 3 emissions.
2. **Data Collection:** Gather detailed data on energy consumption, fuel usage, transportation patterns, waste management, and water consumption.
3. **Carbon Footprint Calculation:** Calculate the carbon emissions from each source using relevant emission factors.
4. **Baseline Emissions Analysis:** Analyze the data to establish a baseline and identify the largest emission sources.

Emissions Inventory for UBT:

Carbon emissions specifically refer to **carbon dioxide (CO2)** released into the atmosphere, primarily from burning fossil fuels, industrial processes, and land use changes such as deforestation. CO2 is the most prevalent greenhouse gas and is often the primary focus in climate change discussions because it represents the largest share of GHG emissions by volume.

Carbon Emission Measurement:
When people refer to "carbon emissions" or a "carbon footprint," they are usually talking about CO2 or CO2 equivalents (CO2e), which is a way to express all GHGs in terms of the amount of CO2 that would have the same warming effect.

Define the Scope of Emissions:

The United States Environmental Protection Agency (EPA) has defined GHG Emissions into three scopes: Scope 1 – direct, reporting company Scope 2 – indirect, upstream activities Scope 3 – indirect, upstream and downstream activities.

- **Scope 1: Direct Emissions** — Emissions from sources directly owned or controlled by UBT.
- **Scope 2: Indirect Emissions** — Emissions from purchased electricity, heat, or steam.
- **Scope 3: Other Indirect Emissions** — Emissions from activities that are not directly owned or controlled but are related to operation.
- **The Table** provides a clear framework for UBT to calculate emissions **from Scopes 1, 2, and 3**. The emissions inventory includes calculating methods and indicators to compute the overall contribution of each emission source, allowing the institution to add them up, **calculate its carbon footprint**, and identify the main sources of emissions that require **prioritized intervention.**

• Scope	Source of emission	Indicator	Calculation method(unit)	Total/year & Contribution in percentage.	Potential Interventions
1	University vehicles Fuel Consumption	Measures the total fuel used in campus vehicles and equipment.	Total Liters or gallons used per year.		
	CO_2 Emissions from university busses and vehicles	Total greenhouse gas emissions from fuel combustion in vehicles and equipment.	Total Fuel Consumption/year × Emission Factor (Metric tons CO2) Coefficient to calculate the emission in metric tons per 100 km for a bus= 0.01, For a car=0.02		
	Refrigerants and Air Conditioning	Emissions from leakage of refrigerants (e.g., HFCs) used in air conditioning and refrigeration	kg of refrigerant/year ×Emission factor varies by refrigerant		

		systems on campus.			
	Emissions from boilers, heaters, generators, and other stationary equipment that burn fossil fuels for heating or electricity.	Gather data on fuel consumption for each stationary source	Liters or cubic meters of fuel/year Emission Factor (Metric tons CO2) Coefficient to calculate the emission in metric tons per 100 km for a bus= 0.01, For a car=0.02		
	Agricultural Activities, such as maintenance of landscaping and gardens, including fuel used in machinery and fertilizers.	Track fuel usage in landscaping equipment and calculate emissions from fertilizers used.	Liters of fuel/year or kg of fertilizer×Emission factor varies		
	Other Direct Combustion Sources such as laboratory equipment or backup generators.	fuel consumption data specific to these processes.	Liters or cubic meters/year×Emission factor varies		
2	Electricity Consumption	Total electricity purchased and consumed by UBT.	(kWh/year)		
	CO_2 Emissions	Emissions associated	Electricity Consumption/year ×		

	from Electricity Use	with electricity purchased from utility providers.	Emission Factor- apply the relevant emission factor for the local electricity grid.		
	Purchased Steam/Heat	Emissions from purchased heating used for building operations.	GJ/year or kWh/year× EF- Varies based on the fuel source used by the utility		
	Purchased Chilled Water	Emissions from the production of chilled water for air conditioning.	kWh/yea× EF r Use the same emission factor as for purchased electricity.		
3	**Upstream** Commuting Emissions	Emissions generated by commuting of students and staff.	Estimated distance traveled /year × Average vehicle emission factor		
	Purchased Goods and Services	Gather expenditure data and identify categories of purchased goods and services. (e.g., office supplies, equipment, services).	Monetary value× emission factor Use an average emissions factor based on spending categories		
	Capital Goods	Collect data on capital expenditures and analyze emissions associated	Monetary value× emission factor Use an average emissions factor based on spending categories		

		with each project. (e.g., buildings, infrastructure).			
	Fuel- and Energy-Related Activities	Analyze fuel consumption data and energy purchase related to the extraction, production, and transportation of fuels and energy that UBT purchases but does not directly consume.	kg CO_2× emission factor Based on energy consumption and regional emissions factors.		
	Down Stream Waste Generation	Total waste generated on campus.	Metric tons of waste per year.		
	CO_2 Emissions from Waste Disposal	Collect data on Emissions from the disposal and treatment of campus waste. (landfill, recycling, incineration).	Tons/year× EF =Metric tons of CO_2. Use emission factors for waste types (e.g., kg .CO_2 per ton of waste).		
	Water Consumption	Total water consumed across campus	Cubic meters (m^3) or gallons/year× EF		

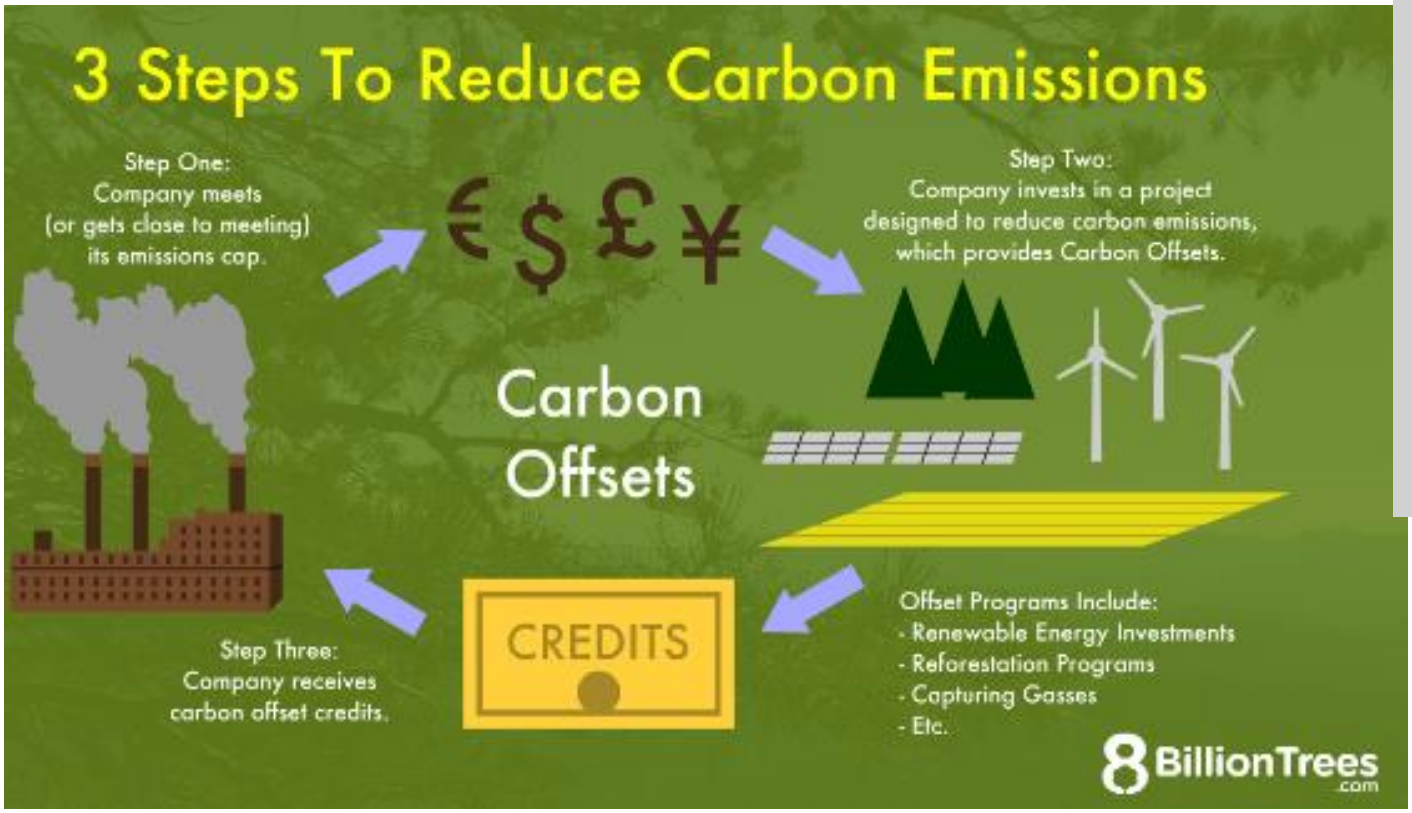
		operations. (e.g., irrigation, sanitation, cooling).	Use an emission factor based on energy used in operation		
	Travel Emissions	Gather data on travel patterns and distance to calculate Emissions associated with travel.	Vehicle km/year× EF Use average emission factors for modes of transport (air, train, car).		
	Use of Sold Products	Estimate usage patterns for sold products and apply appropriate emission factors.	kg/year Emission factors based on product types.		
	Leased Assets	Analyze lease agreements and operational data for leased assets.	kg CO_2/year Use appropriate emission factors for the type of leased asset.		
Overall	Total Carbon Footprint	Total emissions from Scope 1, Scope 2, and Scope 3 sources.	Total Scope 1 + Total Scope 2 + Total Scope 3		
	Emissions Intensity per Student	CO_2 emissions per student, indicating emissions relative to campus population.	Total Emissions/ number of students		

A. Carbon Offsetting Programs

Objective 3: Offset Residual Emissions

Proposed Actions:

- **Invest in Carbon Offsetting Programs**: For emissions that cannot be eliminated, UBT should engage in verified carbon offsetting programs such as reforestation, afforestation, or mangrove planting projects. These projects should prioritize biodiversity, ecosystem restoration, and community engagement.
- **Tree-Planting Initiatives**: Launch tree-planting initiatives on campus and in surrounding areas, focusing on species that are native to the region and offer high carbon sequestration potential. Track the number of trees planted and estimate the CO_2 absorbed annually.
- **Support Reforestation Projects**: Partner with local and international NGOs to support reforestation and afforestation efforts that provide verified carbon offsets, contributing to global carbon neutrality goals.
- **Engage in Carbon Credit Markets**: Purchase certified carbon credits from reputable carbon offset projects, ensuring that the offsets align with UBT's sustainability goals and global standards for emissions reductions.



B. Campus operation and Infrastructure

Objective 1: Ensure Sustainability in Campus Operations

Proposed Actions:

- Conduct an energy audit of campus facilities and install occupancy sensors, starting with a pilot area.
- Decrease water flow rates by installing water-saving filters and leak detection systems.
- Implement a Building Management System (BMS) to optimize energy efficiency.
- Ensure regular maintenance of water-saving devices like low-flow faucets and toilets in all facilities.

Objective 2: Promote Sustainable Projects

Proposed Actions:

- Introduce a green procurement policy prioritizing eco-friendly products.
- Implement a comprehensive campus-wide recycling and waste reduction program.
- Organize electronic waste recycling drives and raise awareness about e-waste.
- Establish a food waste reduction program in campus cafeterias, promoting sustainable dining and composting.
- Develop a sustainable planting strategy using native vegetation and sustainable irrigation.

C. Transportation and Commuting Efficiency

Objective 1: Promote Sustainable Transportation

Proposed Actions:

- Establish a carpooling app for students and staff to facilitate ride-sharing, reducing individual carbon footprints.
- Increase bike-friendly infrastructure on campus by adding bike lanes and secure bike parking.
- Launch a university shuttle service using electric or hybrid vehicles for commuting between campuses.
- **Carbon Initiative:** Provide incentives for students and staff to use public transport or electric vehicles by offering discounts or subsidies.
- **Carbon Neutrality Plan:** Transition the university's entire fleet to electric vehicles by 2030, reducing transportation-related carbon emissions significantly.

Objective 2: Reduce Commuting Emissions

Proposed Actions:

- Partner with local public transportation authorities to offer discounted student and staff passes for buses and trains.
- Encourage telecommuting and remote work options where feasible, reducing the need for daily commutes.
- **Carbon Initiative:** Launch a campaign to raise awareness about the carbon impact of commuting and encourage more eco-friendly travel choices.
- **Carbon Neutrality Plan:** Set a goal to reduce commuting-related emissions by 30% over the next five years by promoting sustainable transportation option.

D. Sustainable Procurement

Objective 1: Implement Sustainable Procurement Policies

Proposed Actions:

- Introduce a green procurement policy prioritizing eco-friendly and carbon-neutral products for campus operations.
- Require suppliers to adhere to sustainability standards and provide carbon footprint information for their products.
- **Carbon Initiative:** Switch to low-carbon office supplies, including recycled paper, biodegradable packaging, and energy-efficient electronics.
- **Carbon Neutrality Plan:** Implement a zero-carbon procurement strategy where all purchased goods and services have a net-zero carbon footprint by 2030.

Objective 2: Promote Lifecycle Analysis in Purchasing Decisions

Proposed Actions:

- Evaluate the lifecycle carbon emissions of products before purchasing, favoring those with lower embodied carbon.
- Incorporate sustainable sourcing in all tenders, contracts, and supplier agreements.
- **Carbon Initiative:** Provide training for procurement staff on evaluating the carbon footprint of products and services.
- **Carbon Neutrality Plan:** Establish carbon reduction targets for the university's supply chain and partner with vendors who actively reduce their carbon emissions.

VIII. Long Term Objective

IX. RESEARCH PROPOSALS

- **Parametric Skin/Green Wall Prototype Design (Smart and Sustainable Wall)**

1. Introduction and Background:

This research project seeks to design and implement a parametric skin/green wall on the university campus, a structure aimed at promoting sustainability and improving air quality. The green wall will function as an innovative system of vertical gardens, incorporating various plant species that are well-suited to the local climate and require minimal maintenance. The broader goal is to enhance the quality of life on campus by reducing air pollution, increasing biodiversity, and providing aesthetically appealing and environmentally friendly spaces for students, staff, and visitors.

In addressing urban challenges like climate change and reduced green spaces, the project aligns with global efforts, such as the United Nations' Sustainable Development Goals (SDGs), specifically Goal 11, which emphasizes the importance of creating sustainable cities and communities. The project is also grounded in the need for universities to serve as living labs, providing innovative solutions that foster environmental consciousness while advancing research and educational opportunities for students.

2. Research Objectives:

The primary objective of the project is to develop a functional and aesthetically pleasing parametric green wall that contributes to sustainability efforts while enriching the campus environment. This research intends to create a vertical garden prototype using cutting-edge technologies like 3D printing, CNC machines, and laser cutting for custom planters and structural elements. The parametric skin will be a dynamic and visually striking green wall capable of being scaled and replicated across different campus locations.

Moreover, the project seeks to provide educational value by involving students from architecture, horticulture, and sustainability-related disciplines. Through hands-on workshops and design competitions, students will gain valuable experience in digital fabrication, sustainable design, and urban gardening. This collaborative effort aims to raise awareness and foster innovation in green infrastructure among the academic community.

3. Methodology:

The research methodology is designed to be both collaborative and iterative, ensuring that every stage of the project maximizes learning and engagement opportunities. The process will begin with a design competition, where students will work in teams to develop conceptual designs for the parametric skin/green wall. The competition encourages creativity and innovation, with mentorship provided by faculty members and researchers specializing in architecture, environmental science, and digital fabrication.

Once the best designs are selected based on specific evaluation criteria, the project will move to the fabrication phase. The Smart and Future Lab for Sustainable Urban Solutions (SFCL) at Ain Shams University will play a key role in this stage. Utilizing state-of-the-art equipment like 3D printers, CNC machines, and laser cutters, the selected designs will be turned into a 1:1 scale prototype of a 60x60 cm tile, representing the first building block of the green wall. This parametric unit will then be digitally fabricated and tested for functionality, including its ability to support selected plant species and maintain smart irrigation systems.

Post-installation studies will be conducted to assess the wall's performance in terms of thermal regulation, humidity control, and overall environmental impact. The project will be monitored closely in collaboration with experts in horticulture and environmental sustainability to ensure the selected plant species thrive and contribute positively to the campus microclimate.

4. Expected Outcomes:

The project is anticipated to yield several important outcomes. First and foremost, it will result in the creation of a digitally fabricated parametric green wall prototype. This prototype will serve as a living lab, providing students with practical experience in sustainability, urban gardening, and advanced digital fabrication techniques. Through workshops and hands-on learning, students will actively participate in the design and implementation phases, gaining skills that are directly applicable to the fields of architecture and sustainable urban design.

Additionally, the project will generate valuable research data that will be shared with the academic community through publications in high-impact journals (Q1/Q2). The data will document the prototype's development, the functionality of the design, and its environmental benefits. The green wall is expected to have measurable impacts on air quality and thermal comfort, both inside and outside the buildings where it is installed.

In the long term, the prototype can be scaled up and implemented on larger building facades across campus. Collaboration with industrial partners will ensure that the design can be adapted and mass-produced for use in other institutions, promoting the integration of green walls into sustainable architecture on a broader scale. This project not only enhances campus life but also serves as a model for universities and organizations globally that are looking to implement sustainable initiatives.

5. Project Significance and Educational Value:

This research holds significant importance for both the university and the wider community. By installing the green wall, the university can reduce its carbon footprint, promote biodiversity, and create an eco-friendly campus that supports the well-being of its occupants. It also provides an opportunity to demonstrate how innovative green infrastructure can play a role in addressing urban environmental challenges.

Moreover, the project serves as a vital educational tool. By involving students in every stage of the process, from initial design to fabrication and installation, the research fosters a hands-on learning experience that enhances their understanding of sustainable design principles. Students studying architecture, environmental science, and related fields will gain practical skills in digital fabrication technologies, which are becoming increasingly important in modern architectural practices.

6. Conclusion:

The parametric skin/green wall project presents an opportunity to advance the university's commitment to sustainability while simultaneously enriching the educational experience of its students. The innovative design, combined with the use of cutting-edge technologies, will create a prototype that enhances the physical environment and contributes to the university's long-term strategy of creating more livable, welcoming, and sustainable spaces. By improving air quality, increasing thermal comfort, and promoting biodiversity, the green wall will not only benefit the campus but also serve as a model for future sustainable urban initiatives.

7. Project Duration and Collaborators:

The project is expected to take nine months to complete, with ongoing collaboration between Ain Shams University's Faculty of Engineering and Agriculture, SFCL Lab, and industrial partners. The involvement of these stakeholders ensures that the green wall can be scaled and applied to real-world settings beyond the university.

In summary, this research project will demonstrate how universities can leverage digital fabrication technologies and sustainable design practices to improve environmental outcomes on their campuses, while also serving as an educational platform for the next generation of architects and sustainability experts (Parametric skin-green w...).

8. Literature review

The increasing expansion of urbanization around the globe has resulted in an increased demand for environmentally responsible practices to be included in urban living environments. Urbanization is accountable for negative environmental consequences, accounting for 70% of worldwide greenhouse gas emissions, according to the United Nations ("SDG 11 — SDG Indicators," 2023) .This is true even though cities account for twenty-five percent of all housing facilities. According to (Li et al., 2019), the decline of green spaces in urban regions is leading to significant challenges such as decreasing air quality and urban heat islands. This is a consequence of the increasing number of people moving to urban areas. Urban planners and designers are investigating more creative ways to incorporate natural components into manmade areas to solve these issues they have. It is common practice to incorporate natural components into constructed spaces through the use of green walls, which are also known as bio-walls (Manso & Castro-Gomes, 2015) and vertical gardens (Fonseca, Paschoalino, & Silva, 2023). According to Palermo & Turco, 2020 and Radić, Dodig, & Auer (2019), green walls not only improve the outward appearance of urban areas, but also offer several advantages to individuals, the economy, and the environment.

Therefore, the objective of this literature review is to investigate the various ways in which green walls could assist in making cities more environmentally friendly, as well as the incorporation of digital technology into such a system. More specifically, the project that is being proposed at the university campus that aims to implement a parametric skin/green wall will be the primary focus of this scholarly investigation. As part of the project, students, instructors, and staff are required to work together in order to create and build the green wall. This project places an emphasis on the importance of community.

Green Wall Benefits

Plants can flourish in urban environments when there is a limited amount of green horizontal space for them to spread out. Green walls are a wall system that is formed by stacking different plants vertically to make a wall (Ascione et al., 2020). In addition to enhancing community interaction (Radić et al., 2019), these installations also have the ability to filter the air, maintain stable temperatures, and promote the cohabitation of plants and animals. It has been established in several studies that green walls have the potential to enhance the air quality in metropolitan areas (Tang, 2023). It is primarily the pollution caused by vehicles and industry that is responsible for the high amounts of particulate matter (PM), nitrogen oxides, and volatile organic compounds that are found in urban areas. By applying green walls, which are extremely successful, it is possible to

greatly reduce the quantity of hazardous pollutants in the air (Perini, Ottelé, Fraaij, Haas, & Raiteri, 2011; Shushunova, Korol, Luzay, & Shafieva, 2023).

Furthermore, green walls significantly enhance air quality by creating a cooling effect on the surrounding air. Evapotranspiration is the process by which plants expel hydrogen vapor into the atmosphere. This process has the potential to bring about a large reduction in the temperatures in the surrounding area. According to (Wahba, Kamil, Nassar, & Abdelsalam, 2019), green walls enable the creation of microclimates that improve both the quality of the air and the comfort level of the temperature. Individuals who reside there as well as the ecosystem will benefit from this. Green walls have the potential to not only clean up tiny particles but also store carbon dioxide, which is a critical greenhouse gas. This would reduce the negative effects of climate change. It is of the utmost importance to enhance the thermal efficiency of buildings in urban areas, as heat islands do not only waste energy but also create discomfort. According to (Cuce, 2017; Mohamed et al., 2020), green walls have the potential to enhance the energy efficiency of a building by controlling the flow of heat and cold air.

Plants growing on top of green walls reduce energy expenses and carbon emissions (Assimakopoulos, De Masi, de Rossi, Papadaki, & Ruggiero, 2020; He, Zhang, Zhang, & Zhou, 2020; Ramadhan & Mahmoud, 2023). They act as a thermal barrier, retaining heat in the summer and rapidly releasing it in the winter, reducing building temperatures by up to 4 degrees Celsius when compared to a standard façade (Oquendo-Di Cosola, Olivieri, Olivieri, & Ruiz-García, 2023; Wahba et al., 2019).

To further strengthen the connection between biodiversity and the numerous ecological benefits, green walls are also an essential component. It is imperative that we comprehend these relationships in order to keep our natural world habitable. According to (Mayrand & Clergeau, 2018), green walls are extremely important in places with high population density because they enhance the diversity of plants and animals and contribute to the preservation of healthy ecosystems. The absence of sufficient green areas in cities results in the fragmentation of the habitats of many different animal species. An improved viewing experience, a reduction in noise (Lacasta et al., 2016), and an improvement in mental wellbeing (Fonseca et al., 2023) are all potential ways in which green walls might enhance the quality of life for city people. In addition to reducing the amount of precipitation that falls, green walls have the ability to treat waste water as well

(da Cunha et al., 2018). Green walls help lessen the danger of floods and water pollution by absorbing and slowing down rain.

Green Wall Types

Throughout the course of history, green walls have been classified into two primary typologies. These typologies have evolved from direct green facades in the hanging gardens of Babylon (Köhler, 2008) to the introduction of living walls in the present day (Kmieć, 2014; Manso & Castro-Gomes, 2015; Ogut, Tzortzi, & Bertolin, 2022). Green walls have been recognized as an essential component for environmentally friendly urban design. Because each category possesses its own set of traits, advantages, and challenges in terms of design, this suggests that new urban uses may be developed for each of the categories.

In order to facilitate the growth of plants as they climb the side of a building, green facades are utilized. Trellis and wire mesh are two examples of structural components that are used in many of these walls. These elements make it easier for plants to develop vertically.

According to (Al-Kayiem, Koh, Riyadi, & Effendy, 2020), you may also make use of a wide range of plants that have green walls, such as vines and perennials! The installation of these systems may be done without causing any damage to the walls that are already in place, and they often require just a little quantity of equipment. As a result, this provides a cost-effective solution for greening urban areas.

According to (Ysebaert, Koch, Samson, & Denys, 2021), living walls are a complicated approach that may be used to cultivate plants in a double-skinned system. There is another name for this method, which is the "vertical garden." The placement of a support, irrigation, and substrate (El Menshawy, Mohamed, & Fathy, 2022) is a common method for accomplishing this goal. This allows the plants to get the water and nutrients they require. There is also the possibility of living walls including flowers, herbs, and tiny bushes. The presence of this system in densely populated cities encourages the development of small ecosystems, which ultimately results in an increase in biodiversity. Additionally, living walls have the potential to be exploited as instructional tools, with the purpose of educating individuals about sustainable gardening techniques, the environment, and several other topics.

In order to make the procedure more complicated, you may need to select the appropriate plants for vertical gardening and take into account the weather conditions in your area. According to (Beck et al., 2018), while selecting plants, it is critically important to take into

account not just their outward look but also their capacity to thrive in specific climates. The amount of sunshine, the humidity, and the fluctuations in the weather are all important aspects to take into consideration (Lacasta et al., 2016; Shushunova, Korol, Luzay, Shafieva, & Bevilacqua, 2022). There are a number of environmental advantages associated with planting native plants. As an illustration, they become more resistant to the effects of natural forces, require less upkeep, and provide food for the native species of the area. In addition, native plants frequently possess features that cause them to be more resistant to diseases and pests (Bianco, Serra, Larcher, & Perino, 2017). These qualities are peculiar to their location, which helps them to exist for a longer period of time after being introduced.

Digital Fabrication integration into Green Walls

Green walls have been updated in terms of both their design and their construction as a consequence of the development of more advanced manufacturing techniques. Three-dimensional printing enables the production of unique items that are optimally suited for any application. The utilization of this technology makes it feasible to create sophisticated designs and create structures that are able to house a broad variety of plants and irrigation systems. This is made possible via the utilization of this technology. The application of 3D printing for the manufacturing of components for green walls has the potential to significantly reduce the amount of trash produced. To accommodate the unique dimensions of the installation site, we can design and construct planters and structures that are unique to the environment. Not only does this increase the functionality and aesthetic value of the green wall, but it also makes it feasible to test and enhance ideas in a short amount of time.

This is made possible by 3D printing, which makes it possible to test ideas rapidly. For the purpose of cutting pieces for green walls, the usage of lasers and computer numerical control (CNC) equipment is significantly more efficient and effective than the more conventional methods that have been utilized in the past. It is possible to develop cuts and designs that are extremely precise thanks to these technologies, which ensures that every component will be able to be assembled in the proper manner. CNC cutting, also known as subtraction fabrication, can improve green wall appearance and durability (Rahman et al., 2023). Laser cutting, on the other hand, allows you to cut a broad variety of materials with a great degree of precision, but it can only cut flat surfaces (Kolarevic, 2001). The process of hand additive manufacturing, on the other hand, entails printing the prototype in a three-dimensional shape that is composed of layers that are cross-sectional (Afify & Elghaffar, 2007). The lifespan of the green wall is increased, its performance is improved,

and the construction process is made more efficient as a result of the employment of these cutting-edge strategies for manufacturing.

Reflections on Literature

For this reason, it is vital to construct the initial models in order to collect input from a number of stakeholders and to have a variety of design possibilities accessible for the green wall system. This is done in order to guarantee that the manufacturing process is carried out at an effective level. The use of prototypes is beneficial because they highlight the difficulties that are experienced when green walls are constructed in the real world. After the development and installation of the parametric skin that was generated using 3D printing, it is required to do periodic maintenance in order to guarantee that the plant is in excellent health and that the system continues to function effectively. The environment is strengthened by the addition of a range of plant species, which in turn reduces the likelihood of getting sick or being infested by pests. By participating in activities that are connected to maintenance, members of the university community have the opportunity to cultivate a strong sense of ownership and accountability among themselves.

Therefore, integrating members of the school community in the ongoing maintenance of the green wall might potentially extend its lifespan and make it more environmentally friendly. People who participate in educational programs and workshops have a better chance of discovering the most efficient methods for maintaining the wellbeing and vitality of the green wall. The people who work in schools, the teachers, and the students are all encouraged to work together on routine maintenance duties in order to foster a sense of community and shared responsibility.

It can be concluded that the construction of a parametric skin or green wall on a college campus has a tremendous deal of potential to enhance the quality of the air, encourage the growth of biodiversity, reduce the amount of heat, and make individuals feel better about themselves. Everyone in the region would participate, and there would be a heightened emphasis on environmental responsibility. This is as a result of the fact that it makes it possible for people from a variety of professions to collaborate with one another, employs creative approaches to design, and involves the entire community of the institution.

9. References

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