ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

THE SOCIAL DIMENSION OF SUSTAINABILITY: A CASE STUDY ON INDOOR ENVIRONMENTAL QUALITY IN TÜRKİYE

M.Sc. THESIS

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ISTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

SÜRDÜRÜLEBİLİRLİĞİN SOSYAL BOYUTU: TÜRKİYE'DE İÇ MEKAN ÇEVRE KALİTESİ ÜZERİNE BİR VAKA ÇALIŞMASI

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Darya-Amini, a M.Sc. student of İTU Graduate School student ID 403211007, successfully defended the thesis/dissertation entitled “THE SOCIAL DIMENSION OF SUSTAINABILITY: A CASE STUDY ON INDOOR ENVIRONMENTAL QUALITY IN TÜRKİYE”, which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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This thesis is dedicated to my parents. Their unwavering support, encouragement, and love have been my constant source of strength and inspiration throughout this journey. Thank you for believing in me and always being there for me.

FOREWORD

The process of finishing this master's thesis has been difficult yet fulfilling, characterized by a deep investigation of the diverse field of sustainability. This thesis examines the social dimension of sustainable development, with a specific focus on Indoor Environmental Quality (IEQ) and its influence on employee productivity and satisfaction in green buildings. To address environmental concerns effectively, it is crucial to embrace a comprehensive sustainability strategy that considers environmental, economic, and social aspects.

This study was inspired by the recognition that while there have been notable improvements in understanding the environmental and economic benefits of green buildings, the social impacts, particularly in the Turkish context, have not been extensively explored. I aim to contribute to the growing knowledge base that supports the development of truly sustainable built environments by bridging this gap. This study intends to offer significant insights to policymakers, construction companies, and other involved parties to underscore the significance of addressing employee health and well-being in their sustainability efforts.

I am profoundly thankful to my adviser, Prof Dr. Mehmet Özgür KAYALICA and professors for their tremendous assistance and support during this research journey, specially Prof. Dr. Hatice SÖZER. Their skills and encouragement have significantly influenced the focus and complexity of this thesis. I am thankful to the employees and experts who took part in this study, providing their time and insights that were essential to the conclusions presented. I hope that our study will encourage more research and practical applications to enhance our shared comprehension and utilization of sustainable development techniques.

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ABBREVIATIONS

AHP	**:** Analytic Hierarchy Process
BIM	**:** Building Information Modeling
BRE	**:** Building Research Establishment
BREEM	**:** Building Research Establishment Environmental Assessment Methodology
CI	**:** Consistency Index
CR	**:** Consistency Ratio
GBCA	**:** General Building Contractors Association
GRIHA	**:** Green Rating for Integrated Habitat Assessment
HK BEAM	**:** Hong Kong Building Environmental Assessment Method
HPI	**:** Health Performance Indicators
HR	**:** Human Resource
HVAC	**:** Heating Ventilation Air Conditioning
IAQ	**:** Indoor Air Quality
IEQ	**:** Indoor Environment Quality
IOM	**:** Institute of Medicine
LEED	**:** Leadership in Energy and Environmental Design
MANOVA	**:** Multivariate Analysis of Variance
MCDM	**:** Multi-Criteria Decision-Making
NABERS	**:** National Australian Built Environment Rating System
NIOSH	**:** National Institute for Occupational Safety and Health
POE	**:** Post Occupancy Evaluation
RI	**:** Random Index
SBS	**:** Sick Building Syndrome
VOC	**:** Volatile Organic Compounds
WGBC	**:** World Green Building Council
WHO	**:** World Health Oraganisation

SYMBOLS

λ_{max}	**:** Maximum Eigenvalue Of The Pairwise Comparison Matrix
n	**:** Order Of The Matrix
H_0	**:** Hypothesis Null
μ_i	**:** Vector of Mean IEQ Scores for the *i*-th Building Type
Y_{ij}	**:** Score on the IEQ Factor for the *j*-th Individual in the *i*-th Building Type
τ_{ij}	**:** Effect of the *i*-th Building Type
ϵ_{ij}	**:** Error Term
P	**:** Significance Value

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THE SOCIAL DIMENSION OF SUSTAINABIILITY: A CASE STUDY ON INDOOR ENVIRONMENTAL QUALITY IN TÜRKİYE

SUMMARY

I conducted a study focusing on social sustainability, which is a crucial feature in today's environment. Extensive literature study revealed that the environmental and economic aspects of sustainability have been extensively studied, whereas the social aspect, especially in the context of Türkiye, has not been given equal emphasis. The lack of research in this area prompted me to investigate the social aspect, particularly concentrating on the efficiency and contentment of employees, which is crucial for organizations. The goal of my analysis was to discover the primary element that impacts employee productivity in the context of sustainability, specifically emphasizing green buildings.

To accomplish this, I sought advice from experts in sustainability, architecture, and management. The experts received a paired questionnaire to rate ten sustainability parameters, including Energy Efficiency, Water Conservation and Management, Indoor Environmental Quality (IEQ), Waste Management and Recycling, Life Cycle Assessment, Long-term Impact, and others. After applying the Analytic Hierarchy Process (AHP) to the data, it was found that Indoor Environmental Quality (IEQ) was identified as the most significant factor impacting employee productivity in office environments.

Acknowledging the crucial importance of Indoor Environmental Quality (IEQ), I advanced to the subsequent stage of my research, which focused on evaluating employee contentment with IEQ in their work environments. I chose three different buildings to compare their compliance with green building standards: the Energy Institute of Istanbul Technical University, a non-certified conventional building; the Istanbul Technical University Graduate School Building, which is Platinum LEED certified and features smart systems such as smart lighting and elevators; and the NEF Building, a LEED-certified green building with limited smart systems.

During this portion of the investigation, I arranged multiple in-person meetings with individuals who work in these buildings. I delivered a detailed questionnaire with around 40 questions during these exchanges. The questions were created to investigate many elements of Indoor Environmental Quality (IEQ), such as air quality, temperature, lighting, acoustics, and views. I aimed to gain a comprehensive grasp of how employees viewed the Indoor Environmental Quality (IEQ) in their individual office settings.

The questionnaire results were analyzed using the MANOVA methodology in SPSS software. This statistical method facilitated a detailed analysis of the data to detect any notable variations in employee satisfaction with IEQ among the three building types.

The results showed that there were no significant differences in employee satisfaction with Indoor Environmental Quality (IEQ) among the three buildings. Employees indicated similar levels of satisfaction with their indoor settings, regardless of the different green certification levels and advanced smart systems present. The surprising result indicated that the investments in obtaining green certifications and implementing smart technologies may not be leading to improved employee satisfaction with Indoor Environmental Quality (IEQ).

This discovery has significant consequences for the construction sector, legislators, and other parties engaged in the planning and development of environmentally friendly buildings. The statement emphasizes a significant flaw in existing sustainable construction methods: the importance of prioritizing and adequately managing Indoor Environmental Quality (IEQ) variables that have a direct influence on staff well-being and efficiency. The environmental advantages of green buildings are widely recognized, but the social aspect, especially employee satisfaction and productivity, needs more focus and incorporation into the design and construction procedures.

My analysis highlights the importance of adopting a comprehensive approach to green construction requirements. It promotes a balance between environmental sustainability and the social factors that enhance the well-being and productivity of building inhabitants. By prioritizing Indoor Environmental Quality (IEQ), stakeholders may guarantee that green buildings achieve not just environmental objectives but also establish healthy, comfortable, and productive settings for employees.

Ultimately, green buildings are a crucial advancement in sustainability, but this research emphasizes the necessity of taking social concerns, including Indoor Environmental Quality (IEQ), into account during their design and execution. It is important for policymakers, construction businesses, and other relevant industries to consider these findings and make employee wellness a top priority in their sustainability initiatives. This method will improve the efficiency of green buildings and support the broader objective of sustainable development, including environmental, economic, and social aspects.

SÜRDÜRÜLEBİLİRLİĞİN SOSYAL BOYUTU: TÜRKİYE'DE İÇ MEKAN ÇEVRE KALİTESİ ÜZERİNE BİR VAKA ÇALIŞMASI

ÖZET

Giriş

Günümüz dünyasında sürdürülebilirliğin kritik önemi ışığında, sürdürülebilirliğin genellikle göz ardı edilen bir yönü olan sosyal sürdürülebilirlik üzerine bir çalışma yapmaya karar verdim. Geniş kapsamlı bir literatür taraması sonucunda, sürdürülebilirliğin çevresel ve ekonomik boyutlarının ayrıntılı bir şekilde araştırılmış olmasına karşın, özellikle Türkiye bağlamında sosyal yönün aynı düzeyde ilgi görmediği ortaya çıktı. Bu araştırma boşluğu, beni sosyal boyutu, özellikle de işletmelerin gündeminde yer alan çalışanların verimliliği ve memnuniyeti konularına odaklanarak incelemeye teşvik etti. Çalışmam, sürdürülebilirlik bağlamında çalışan verimliliğini etkileyen en önemli faktörü, özellikle yeşil binalara odaklanarak belirlemeye yönelikti.

Araştırma Süreci

Bu amacı gerçekleştirmek için sürdürülebilirlik, mimarlık ve yönetim gibi çeşitli alanlardan uzmanlarla görüştüm. Bu uzmanlara, enerji verimliliği, su koruma ve yönetimi, iç çevre kalitesi (IEQ), atık yönetimi ve geri dönüşüm, yaşam döngüsü değerlendirmesi, uzun vadeli etki ve diğerleri gibi on kritik sürdürülebilirlik faktörünü sıralamak için bir çiftli karşılaştırma anketi sunuldu. Toplanan verileri analiz etmek için Analitik Hiyerarşi Süreci (AHP) kullanıldı ve iç çevre kalitesinin (IEQ) ofis ortamlarında çalışan verimliliğini etkileyen en önemli faktör olduğu ortaya çıktı.

IEQ'nun Önemi

İç çevre kalitesinin merkezi rolünü kabul ederek, çalışmamın bir sonraki aşaması, çalışanların iş yerlerindeki IEQ ile memnuniyetini değerlendirmeyi amaçladı. Bu amaçla, yeşil bina standartlarına uyum açısından farklılık gösteren üç ayrı bina seçtim: İstanbul Teknik Üniversitesi Enerji Enstitüsü, yeşil sertifikası olmayan geleneksel bir bina; akıllı aydınlatma ve asansör sistemleri gibi akıllı sistemler içeren Platin LEED sertifikalı İstanbul Teknik Üniversitesi Lisansüstü Okulu Binası; ve geniş kapsamlı akıllı sistemlere sahip olmayan LEED sertifikalı NEF Binası.

Anket Hazırlığı ve Dağıtımı

Bu araştırma aşamasında, bu binalarda çalışanlarla yüz yüze birçok görüşme düzenledim. Bu görüşmeler sırasında, yaklaşık 40 sorudan oluşan kapsamlı bir anket dağıttım. Bu sorular, hava kalitesi, sıcaklık, gün ışığı, akustik ve manzara gibi çeşitli IEQ yönlerini sorgulamayı amaçlıyordu. Amacım, çalışanların ilgili ofis ortamlarındaki IEQ'yu nasıl algıladıklarına dair bütünsel bir anlayış elde etmekti.

Anket Sonuçlarının Analizi

Anketlerden toplanan yanıtlar, SPSS yazılımı aracılığıyla MANOVA metodolojisi kullanılarak analiz edildi. Bu istatistiksel yaklaşım, verilerin ayrıntılı bir incelemesini sağlayarak, üç bina arasında IEQ ile ilgili çalışan memnuniyetinde önemli farklılıklar olup olmadığını belirlemeyi amaçladı. Beklenmedik bir şekilde, sonuçlar, üç bina arasında IEQ ile ilgili çalışan memnuniyeti açısından önemli bir fark olmadığını ortaya

koydu. Yeşil sertifikaların ve ileri düzeyde akıllı sistemlerin varlığına rağmen, çalışanlar iç ortam kalitelerinden benzer düzeyde memnuniyet bildirdiler.

Bulguların Değerlendirilmesi

Bu beklenmedik sonuç, yeşil sertifikalar elde etmek ve akıllı sistemler entegre etmek için yapılan yatırımların, IEQ ile ilgili çalışan memnuniyetini artırmaya doğrudan dönüşmeyebileceğini düşündürdü. Bu bulgu, inşaat sektörü, politika yapıcılar ve yeşil binaların tasarımı ve inşasıyla ilgili diğer paydaşlar için derin sonuçlar doğurmaktadır. Mevcut yeşil bina uygulamalarındaki kritik bir gözden kaçırmayı vurgulamakta: çalışan sağlığı ve verimliliğini doğrudan etkileyen IEQ faktörlerine öncelik verme ve etkin bir şekilde ele alma gerekliliği.

Yeşil Binaların Sosyal Boyutu

Yeşil binaların çevresel faydaları iyi bilinirken, sosyal boyut, özellikle de çalışan memnuniyeti ve verimliliği, tasarım ve inşaat süreçlerine daha fazla entegrasyon gerektirmektedir. Bu içgörüler doğrultusunda, çalışmam, yeşil bina standartlarına daha bütünsel bir yaklaşımın gerekliliğini vurgulamaktadır. Çevresel sürdürülebilirlik ile bina kullanıcılarının refahı ve verimliliğine katkıda bulunan sosyal yönler arasında bir denge sağlanmasını savunmaktadır.

Politika ve Uygulamalar

IEQ'ya daha fazla odaklanarak, paydaşlar, yeşil binaların sadece çevresel hedeflere ulaşmakla kalmayıp aynı zamanda çalışanlar için sağlıklı, konforlu ve verimli ortamlar yaratmasını sağlayabilir. Bu yaklaşım, hem çalışan memnuniyetini artıracak hem de iş verimliliğine olumlu katkılarda bulunacaktır.

Sonuç ve Öneriler

Sonuç olarak, yeşil binalar sürdürülebilirlik yolunda önemli bir adım olmakla birlikte, bu çalışma, tasarım ve uygulamada sosyal faktörlerin, özellikle IEQ'nun dikkate alınmasının önemini vurgulamaktadır. Politika yapıcılar, inşaat şirketleri ve diğer ilgili sektörler, bu bulguları dikkate almalı ve sürdürülebilirlik çabalarında çalışan sağlığını önceliklendirmelidir.

Çalışan Sağlığı ve Verimliliği

Bu yaklaşım, yeşil binaların etkinliğini artıracak ve çevresel, ekonomik ve sosyal boyutları kapsayan genel sürdürülebilir kalkınma hedefine katkıda bulunacaktır. Çalışan sağlığı ve verimliliğini artırmak, sadece bireylerin refahını değil, aynı zamanda işletmelerin genel performansını da iyileştirecektir.

Gelecekteki Araştırmalar

Gelecekte, bu alandaki araştırmaların genişletilmesi ve daha fazla veri toplanması, daha derinlemesine anlayışlar sağlayabilir. Özellikle farklı sektörlerde ve farklı bina türlerinde yapılan çalışmalar, IEQ'nun çalışan memnuniyeti ve verimliliği üzerindeki etkilerini daha iyi anlamamıza yardımcı olabilir.

Uygulamalı Öneriler

Bu araştırma, politika yapıcılara ve inşaat sektörüne yönelik birkaç önemli uygulamalı öneri sunmaktadır. İlk olarak, yeşil binaların tasarımı ve inşasında IEQ'nun önceliklendirilmesi gereklidir. Bu, iç mekan hava kalitesi, aydınlatma, akustik ve termal konfor gibi unsurların dikkatlice değerlendirilmesini ve iyileştirilmesini içerir. Çalışanların bu faktörlerle ilgili memnuniyeti, genel iş verimliliğini ve sağlığını doğrudan etkileyebilir. Bu nedenle, bina tasarımında IEQ faktörlerinin daha fazla dikkate alınması, çalışanların daha sağlıklı ve verimli çalışma ortamlarına sahip olmasını sağlayacaktır.

İkinci olarak, bina yönetim sistemleri ve akıllı teknoloji entegrasyonunda, çalışanların ihtiyaç ve memnuniyet düzeylerine odaklanılması önemlidir. Örneğin, akıllı aydınlatma ve iklimlendirme sistemleri, çalışanların bireysel ihtiyaçlarına göre ayarlanabilir olmalıdır. Bu tür teknolojik çözümler, enerji verimliliği sağlarken aynı zamanda çalışanların konforunu da artırabilir.

Üçüncü olarak, yeşil binaların kullanıcı geri bildirimlerine dayalı olarak düzenli olarak değerlendirilmesi ve iyileştirilmesi gerekmektedir. Çalışanlardan düzenli olarak IEQ hakkında geri bildirim almak ve bu geri bildirimleri bina yönetimi ve tasarım süreçlerinde kullanmak, yeşil binaların sürekli olarak optimize edilmesine yardımcı olacaktır. Bu yaklaşım, hem çevresel sürdürülebilirlik hedeflerine ulaşmayı hem de çalışan memnuniyetini artırmayı mümkün kılacaktır.

Son olarak, eğitim ve farkındalık artırma programları ile çalışanların yeşil bina uygulamaları ve IEQ'nun önemi hakkında bilgilendirilmesi teşvik edilmelidir. Çalışanların, çalışma ortamlarındaki sürdürülebilir uygulamalar ve IEQ'nun sağlıkları ve verimlilikleri üzerindeki etkileri hakkında bilinçlenmesi, bu faktörlerin öneminin daha iyi anlaşılmasını ve desteklenmesini sağlayacaktır.

Sonuç

Sonuç olarak, yeşil binalar sürdürülebilirlik yolunda önemli bir adım olmakla birlikte, bu çalışma, tasarım ve uygulamada sosyal faktörlerin, özellikle IEQ'nun dikkate alınmasının önemini vurgulamaktadır. Politika yapıcılar, inşaat şirketleri ve diğer ilgili sektörler, bu bulguları dikkate almalı ve sürdürülebilirlik çabalarında çalışan sağlığını önceliklendirmelidir.

Çalışan sağlığı ve verimliliğini artırmak, sadece bireylerin refahını değil, aynı zamanda işletmelerin genel performansını da iyileştirecektir. Çalışan memnuniyeti yüksek olan iş yerleri, daha yüksek verimlilik, daha düşük devamsızlık oranları ve daha iyi iş kalitesi gibi birçok avantaj sağlayabilir. Bu da işletmelerin rekabet gücünü artıracaktır.

Gelecekte, bu alandaki araştırmaların genişletilmesi ve daha fazla veri toplanması, daha derinlemesine anlayışlar sağlayabilir. Özellikle farklı sektörlerde ve farklı bina türlerinde yapılan çalışmalar, IEQ'nun çalışan memnuniyeti ve verimliliği üzerindeki etkilerini daha iyi anlamamıza yardımcı olabilir. Bu tür çalışmalar, yeşil bina standartlarının geliştirilmesine ve iyileştirilmesine katkıda bulunacaktır.

Ayrıca, bu araştırma sonuçlarının ulusal ve uluslararası düzeyde politika oluşturma süreçlerinde dikkate alınması gerekmektedir. Sürdürülebilir kalkınma hedeflerine ulaşmak için, politika yapıcıların ve sektör liderlerinin, çalışan sağlığı ve verimliliğini destekleyen IEQ standartlarını benimsemeleri ve uygulamaları teşvik edilmelidir.

Sonuç olarak, sürdürülebilirlik çabalarında sadece çevresel ve ekonomik boyutların değil, sosyal boyutların da dikkate alınması gerektiği açıktır. Çalışan sağlığı ve

memnuniyeti, sürdürülebilir kalkınmanın temel bileşenlerindendir ve bu alanda daha fazla araştırma ve uygulama gerekmektedir. Yeşil binaların tasarım ve inşasında sosyal sürdürülebilirliğin önemi göz ardı edilmemeli, çevresel faydaların yanı sıra çalışanların refahını da en üst düzeye çıkaran çözümler geliştirilmelidir. Bu yaklaşım, yeşil binaların etkinliğini artıracak ve çevresel, ekonomik ve sosyal boyutları kapsayan genel sürdürülebilir kalkınma hedefine katkıda bulunacaktır.

1. INTRODUCTION

Currently, numerous buildings have been built or renovated to promote sustainable development and minimize the impact of global warming and climate change on the residents. Indoor Environmental Quality is a crucial factor in assessing green building practices for sustainable development. In previous study, individuals have often overlooked the significance of interior environmental quality in a facility. Many designers and builders lack a feedback loop after construction, hindering their ability to enhance design and building processes for better indoor environmental quality.

Indoor Environmental Quality (IEQ) pertains to the total comfort and health of a building's interior environment and its occupants. IEQ is strongly connected to global environmental issues such as global warming and climate change, as they both impact the indoor environmental quality of a building. Global warming and climate change's effects on interior settings and the health of individuals who spend time indoors have not been widely studied. Buildings created for historical climate conditions may not function well under new ones, impacting residents. The Institute of Medicine (IOM) discovered that poor indoor environmental quality leads to health issues that hinder occupants' ability to work and learn. This situation can worsen existing indoor environmental problems and create new challenges. However, it also presents opportunities to improve public health while addressing changes in indoor environmental quality caused by climate change. The IOM has determined that climate change directly impacts indoor environmental quality, necessitating focused attention and action.

An imbalance in Indoor Environmental Quality (IEQ) can lead to Sick Building Syndrome (SBS) and trigger various ailments in the building occupants. Sick Building Syndrome (SBS) refers to a condition when residents suffer from immediate health and comfort issues that appear to be related to the time spent within a building, however the precise ailment or cause is not clearly identified. World Health Organization (WHO) reported that 30% of new and refurbished buildings globally are associated with Sick Building Syndrome (SBS) symptoms. This is because the buildings are not continuously managed or maintained according to their original designs or recommended operating procedures. IEQ clearly warrants more focus at all stages of building development: pre-construction, construction, and post-construction.

The National Institute for Occupational Safety and Health (NIOSH) states that indoor environments are crucial for public health as occupants spend a significant amount of time indoors. Exposures to contaminants in buildings where they work can lead to health conditions or symptoms, and individuals may experience relief when they are not in the building. According to NIOSH's previous investigation, indoor environmental pollutants originate from within the building or are brought in from outdoors. Various contaminants in the form of gases and particles from office equipment, cleaning supplies, construction work, carpets, furniture, perfumes, cigarette smoke, water-damaged materials, microbial growth (fungi/mold and bacteria), insects, and outdoor pollutants can expose occupants to harmful substances.

Optimal indoor conditions are essential for a structure to be considered sustainable or environmentally friendly. Instead than focusing on designing or redesigning buildings, the performance of each component within the buildings that contributes to the bad indoor environment should be enhanced. The following components require careful consideration: indoor air quality, ventilation, thermal comfort, temperature, humidity, wind flow, lighting comfort, and noise. These will be elaborated on in the upcoming chapter.

The major goal of this study is to evaluate the Indoor Environmental Quality of the Energy Institute of Istanbul Technical University, the Graduate School Building of Istanbul Technical University, and the NEF Istanbul Office Building. Evaluating Indoor Environmental Quality (IEQ) is crucial to maintain optimal performance and health for staff. Regardless of the impressive architecture and interior of the facility, a badly constructed indoor environment can significantly impact the health, performance, and productivity of occupants.

1.1 Purpose of Thesis

Sustainability has emerged as a pivotal concept in contemporary architectural and corporate practices, addressing the urgent need for environmental stewardship. However, the social aspect of sustainability, which emphasizes human well-being and satisfaction, is often overlooked. This study aims to bridge that gap by examining how the social dimension, particularly employee satisfaction and productivity, can be integrated into sustainable building practices. Our research focuses on employees working in Leadership in Energy and Environmental Design (LEED)-certified offices, investigating how these green buildings impact their work experience.

In today's work environment, employee satisfaction and productivity are critical for organizational success. The physical work environment plays a significant role in influencing these factors. Given the growing trend of green building certifications like LEED, it is crucial to understand how these buildings affect the occupants. LEED certification encompasses various sustainability criteria, such as energy efficiency, water management, site selection, and waste management. However, among these, Indoor Environmental Quality (IEQ) has emerged as a particularly influential factor.

To address this issue comprehensively, we adopted a two-step approach. In the first step, we consulted a diverse group of experts from various fields, including architecture, environmental science, occupational health, and human resources. This interdisciplinary panel provided a holistic perspective on the elements that contribute to employee productivity and satisfaction in green buildings. Using the Analytical Hierarchy Process (AHP), a structured technique for organizing and analyzing complex decisions, the experts were able to systematically identify and prioritize these factors.

The AHP process revealed that while all sustainability factors are important, IEQ stands out as the most critical for employee well-being. IEQ encompasses various elements such as air quality, lighting, thermal comfort, and acoustics, which directly affect how employees feel and perform in their workspace. Good IEQ can reduce health issues, enhance concentration, and improve overall job satisfaction, making it a focal point for sustainable building practices.

In the second step of our research, we conducted a comprehensive survey targeting employees working in LEED-certified offices. The survey aimed to capture their perceptions and satisfaction levels regarding their indoor environmental quality. The questionnaire included items on air quality, lighting conditions, noise levels, and temperature control, among other factors. By gathering data directly from the occupants, we could obtain an authentic understanding of their experiences and preferences.

To analyze the survey responses, we utilized the Statistical Package for the Social Sciences (SPSS) software. SPSS is a powerful tool for managing and analyzing data, and it was instrumental in our application of Multivariate Analysis of Variance (MANOVA). MANOVA is a statistical technique that allows for the examination of

multiple dependent variables simultaneously, enabling us to understand the complex relationships between different aspects of IEQ and overall employee satisfaction and productivity.

The use of SPSS facilitated a rigorous analysis of the data, ensuring that our findings were both reliable and valid. Through MANOVA, we were able to determine the impact of various IEQ factors on employee outcomes and identify which specific elements of the indoor environment were most influential. This analysis provided insights into how different aspects of IEQ interact to affect employee well-being and performance.

Our findings underscore the importance of prioritizing IEQ in the design and operation of green buildings. While energy efficiency and other environmental factors are vital, the human-centric aspect of sustainability should not be neglected. By focusing on IEQ, organizations can create healthier, more comfortable, and more productive work environments. This approach not only benefits employees but also enhances organizational performance and sustainability.

Moreover, this study highlights the need for a balanced approach to sustainability that considers environmental, economic, and social dimensions. By integrating the social aspect, particularly employee well-being, into sustainability frameworks, we can achieve more holistic and effective outcomes. Our research provides a roadmap for organizations seeking to optimize their green building initiatives for maximum human and environmental benefits.

In conclusion, this study contributes to the growing body of knowledge on sustainable building practices by emphasizing the social dimension. It offers practical insights for architects, facility managers, and organizational leaders on how to enhance employee satisfaction and productivity through improved IEQ in LEED-certified offices. By prioritizing the well-being of the people who occupy these spaces, we can make significant strides towards truly sustainable and resilient building practices.

2. LITERATURE REVIEW

2.1 Chapter Overview

An overview of green buildings is given in this chapter, along with information on the idea of green buildings, elements that affect employee happiness and productivity in green buildings, and a comparison of green and conventional non-green building features. There are three sections to this chapter. A general overview of green buildings and the many certifications they might receive are covered in the first part. In order to identify a research need, the division employs a thorough examination of the literature on productivity and well-being in green buildings. Examining the scientific literature on the effects of green buildings on productivity and well-being is the main goal of the systematic review. The research focus of this study is clearly established by the thorough literature review.

2.2 Green Building Context

Because they benefit the environment and the people who live in them, green buildings have generated interest in the built environment. It is important to comprehend the three interconnected challenges that are related to the consequences of green buildings (Eichholtz et al., 2010). The first concerns the items—components, framework, and controls—necessary to receive certification for green buildings. Concern number two is about the people or organizations that are involved, including the government, investors, designers, engineers, architects, owners, tenants, and employers. The third issue relates to the processes or results, including management, performance, and upkeep. This section discusses three main topics that shed light on how green buildings affect their tenants. The background of green buildings, the parties involved, and their potential are also covered in this section.

Studying green buildings is highly popular around the world because of their potential to advance sustainability. The built environment sector, governments, private companies, and the general public all support green construction initiatives (Zuo & Zhao, 2014). When discussing buildings, the words "green building," "sustainable building," "high-performance building," "energy-efficient building," "low-carbon building," "high-quality building," and "intelligent building" are frequently used in conjunction with one another (Kozusznik et al., 2019). In this thesis, all of these

concepts are classified as "green buildings". The term "green buildings" (GBs) has no clear definition (Zuo & Zhao, 2014). According to USEPA (2016), a green building is one that is created with well-integrated systems and procedures to reduce resource usage across the building's whole life cycle. High interior environmental quality (IEQ), effective daylighting, material reuse and recycling, and waste minimization are characteristics of green buildings (Kibert, 2016). According to the World Green Building Council (WGBC 2017), because green buildings can significantly lower construction-related carbon emissions, they may eventually supplant conventional structures. A green building, according to Dwaikat and Ali, is a business place that is environmentally conscious and uses fewer natural resources during both construction and operation (Dwaikat & Ali, 2016). Whether a building is brand-new, already-existing, or renovated, it qualifies as a "green building" if it has received certification as such from an appropriate body or if it has been built and maintained in compliance with certain standards (Wener & Carmalt, 2006). Though definitions differ, most agree that a building can be considered "green" if it strives to be environmentally friendly and supports a healthy ecosystem.

A grading system is sometimes a requirement for a building to obtain "green" certification. The establishment of the Building Research Establishment Environmental Assessment Methodology (BREEAM) in 1990 initiated the certification process for green buildings (Gowri, 2004). Several sustainable construction evaluation frameworks have gained popularity in specific nations throughout the past twenty years. Some examples of green building certifications include Leadership in Energy and Environmental Design (LEED) in the United States, Promise in Finland, ECO-PRO in Germany, the Hong Kong Building Environmental Assessment Method (HK BEAM) in China, LEED India, Green Rating for Integrated Habitat Assessment (GRIHA) in India, Green Star in South Africa, and Green Star and National Australian Built Environment Rating System (NABERS) in Australia.

Various nations adhere to distinct construction codes. This study primarily contrasts Australia's Green Star (created in 2003) and India's NABERS (announced in 2000) rating systems with India's LEED (introduced in 1993) while analyzing green buildings in Australia and India. LEED, Green Star, and NABERS are not interchangeable. A Platinum LEED building is of the same standard as a six-star building, a Gold LEED building is on par with a five- or four-star structure, a Silver

LEED building is similar to a three-star building, and a certified LEED building is comparable to a one- or two-star building (BRE 2008). The concept of global leadership is associated with buildings that have achieved a rating of six stars. Australian excellence is represented by buildings with a rating of five stars. Best practice is reflected in buildings with a rating of four stars. Excellent practice is demonstrated by buildings with a rating of three stars. Average practice is represented by buildings with a rating of two stars. Lastly, minimal practice is indicated by buildings with a rating of one star (GBCA 2009). The NABERS rating system employs a five-star scale to evaluate building performance. A five-star rating signifies exceptional performance, while four stars indicate strong and excellent performance. Three stars indicate very good adherence to current market best practices, two stars indicate average building performance, and one star is assigned to buildings with inadequate energy management or outdated systems (NABERS 2019). Various certifications grant credits for professional practice based on specific criteria, including the geographical location of the construction site, the ecological impact throughout the entire construction process and during operations, the use of water- and energy-efficient materials, and the reduction of waste related to sewage and refrigerants. Identifying and acknowledging good Indoor Environmental Quality (IEQ), which prioritizes improving the amount of natural light, access to outdoor views, comfortable temperature, proper ventilation, low levels of harmful substances, and minimal noise, is a crucial element of this collection of tools (Al Horr et al., 2016; Altomonte et al., 2019a; Steinemann et al., 2017; Xiong et al., 2015). The instruments primarily assess the ability of the constructed environment to meet sustainability standards by utilizing indications for future progress. Stakeholders voluntarily embrace these recommendations to augment and advocate for their ecologically conscious building design strategy (Eichholtz et al., 2013). The technical aspects of these certificates are highlighted in the comprehensive research on green buildings as qualifying benefits of green buildings. The preferences and behaviors of the individuals using these categories are unclear (Ding et al., 2016).

The perception of green building performance is undergoing a transformation, moving away from a primary emphasis on sustainability and instead highlighting the importance of inhabitants as proactive participants (Brown & Cole, 2009). If the inhabitants of a green building lack the necessary knowledge to utilize its eco-friendly

characteristics, the building may operate in a manner comparable to a traditional building. The presence of natural ventilation and daylighting has been linked to decreased stress levels, higher moods, and improved energy efficiency in buildings. The building's performance and overall productivity may be hindered by a lack of awareness or information among residents regarding natural ventilation or daylighting. Furthermore, the advantages of green buildings may not become apparent until the building occupants fully utilize the facility according to its intended purpose (Antonelli, 2008; Day & Gunderson, 2015).

2.2.1 Potential outcomes for green buildings

When assessing the possible effects of green buildings, it is important to examine other factors in addition to sustainability. Until now, the primary emphasis has been on technological factors, such as Indoor Environmental Quality (IEQ), as the cause for the enhanced productivity and health in green buildings. Nevertheless, the assertions made by Thatcher and Milner in 2016 may be lacking in substance. Historically, the main emphasis on gaining green building certification has been on the environmental aspect, neglecting the social and economic aspects of sustainability, despite the fact that sustainability encompasses all three dimensions. Key stakeholders in the advancement of sustainable buildings are working towards achieving a balance between social responsibility, environmental effects, and economic considerations (Cajias et al., 2012; Walker et al., 2016). This subsection examines the potential outcomes of green building design on the environmental, economic, and social aspects of the triple bottom line. It aims to offer readers with a thorough understanding of these areas.

The design of the green building provides a multitude of environmental advantages. Green buildings are widely recognized for their ability to significantly decrease carbon emissions across their entire life cycle, encompassing construction, maintenance, and operation. A comprehensive investigation has been conducted on the ecological advantages, specifically focusing on the efficiency of water and resources (Zuo & Zhao, 2014). Green buildings have lower operating energy consumption compared to conventional buildings due to features like recycling and energy reuse, leading to overall energy savings in these structures (Agha-Hossein et al., 2013; Azar et al.,

2016). Furthermore, green buildings are more efficient than conventional constructions as they generate electricity on-site utilizing photovoltaic systems.

The concept of "green building design" now encompasses environmental sustainability, as well as the social and economic aspects of sustainability. Altomonte et al. stated that green buildings' entire life cycle is associated with cost savings due to their reduced energy consumption, resulting in decreased operating expenses (Altomonte et al., 2019a; Shi et al., 2013). Non-monetary or intangible economic advantages resulting from improved performance in green buildings have superseded the monetary benefits connected with the reduced consumption of water, waste, and energy in these buildings (Day & Gunderson, 2015; Hoffman & Henn, 2008). Enhanced productivity or performance of individuals in business, hospital, or school environments are examples that demonstrate these intangible advantages (Hoffman & Henn, 2008). The productivity of residents is a key factor in understanding the financial aspects of green building design, as it represents about 90% of an organization's overall operating expenses (WGBC 2017).

A movement is gaining momentum to include social sustainability into green buildings (Jensen et al., 2012). The social sustainability of green buildings include the productivity outcomes, well-being, and overall quality of life of the individuals occupying the building (Zuo & Zhao, 2014). Research indicates that the main elements that motivate the implementation of green building techniques are the tangible financial advantages, such as reduced operating expenses, and the intangible ones, such as enhanced performance of building occupants (Day & Gunderson, 2015; Hoffman & Henn, 2008). Employers are strongly encouraged to engage in green building design because of the possible economic advantages it provides. Green buildings are important for tenants because to the multitude of advantages they provide, including increased productivity, improved environmental comfort, occupant satisfaction, and good effects on psychological and physiological well-being (Day & Gunderson, 2015). Green buildings strive to cater to the behavioral, psychological, and social requirements of their occupants. Therefore, the success of a green building can be influenced by the behavior of its users (Wener & Carmalt, 2006). According to Wener and Carmalt, the efficiency of a building in green construction is mostly decided by the building's behavior rather than the degree of design (Wener & Carmalt, 2006). The energy efficiency of a green building can be influenced by the interactions

and activities of its tenants (Day & Gunderson, 2015). Although there is a growing emphasis on sustainable construction technologies, it is still crucial to understand the behavioral and psychological effects of green buildings (J. H. Heerwagen & Heerwagen, 2000; Wener & Carmalt, 2006).

Understanding the complex and interwoven issues related to individuals, materials, and procedures in the creation of environmentally friendly buildings can be challenging (Brown & Cole, 2009). Surveys and other post-occupancy evaluation (POE) tools do not have the capability to link behavioral and psychological challenges to the effectiveness of green buildings (Brown et al., 2010). Enhancing environmental quality is usually associated with the construction elements of green building design. There is limited data linking a facility's strategic effectiveness for the business with its green building design (J. H. Heerwagen & Heerwagen, 2000). The social aspect of successful green building projects is still developing, even if there has been notable progress in the environmental and economic aspects (Hoffman & Henn, 2008). Most research on the effectiveness of green buildings relies on post-occupancy evaluations (POEs), showing that Indoor Environmental Quality (IEQ) enhances occupant performance (Kamaruzzaman et al., 2011). Tenants benefit from certifications such as LEED (Baird, 2011; Rashid et al., 2012).

Cohen (2007) identified three analytical levels that can be used to elucidate the advantages of the social aspects of green building design. Improving personal productivity and wellness can be accomplished on an individual basis. From a societal perspective, attracting talent is a substantial advantage. Maximizing productivity and ensuring the well-being of employees are crucial elements for achieving social sustainability in green buildings within a business environment (Hong et al., 2017). Hong et al. emphasized that the most effective method to assess the current status of social sustainability in green buildings is by implementing behavioral interventions on building occupants by stakeholders at the owner, tenant, or manager level (Hong et al., 2017). Roetzel and Chen pointed out that social-psychological aspects affecting tenants' behavior are their attitudes, subjective behavior control, and perceived behavior control (Roetzel & Chen, 2016). This study centers on the issues related to well-being and productivity in green buildings.

Improving productivity has a significant impact on the socioeconomic performance of green building design. Productivity is the quantitative measure of the efficiency of a

system, calculated by dividing the total output by the total input. Hwang, Zhu, and Ming classified management variables as factors that impact productivity in the built environment, alongside project, human resource, external, and technological components (B.-G. Hwang et al., 2017). Measuring productivity can be a difficult endeavor that frequently requires the use of quantitative data to evaluate operational efficiency (Al Horr et al., 2016). Subjective productivity is an alternative method for assessing productivity. Surveys are employed to collect individuals' perspectives on their personal levels of productivity (Feige et al., 2013a; Miller & Davis, 2009). Research has revealed a more robust association between productivity and parameters related to Indoor Environmental Quality (IEQ) in certified green buildings. The responses of occupants in self-assessment surveys that connect Indoor Environmental Quality (IEQ) with productivity are frequently influenced by the biased character of their answers when they are conscious of being evaluated (Byrd & Rasheed, 2016). Self-assessed productivity is a vital indicator of productivity that aids in assessing organizational metrics such as occupants' social interaction, personal comfort, and behavioral consequences (Miller & Davis, 2009). Research has demonstrated a correlation between occupant contentment and self-reported efficiency when occupants are granted independence in controlling their surroundings (Gou et al., 2014). By including employees in the design features of the building, it can greatly affect their overall pleasure, thereby impacting their job satisfaction.

One sustainable impact of green buildings concerning employees is their well-being (Hong et al., 2017). Comfort can be seen as the intersection where subjective indicators such as happiness and objective measures such as health meet on the well-being spectrum (Steemers & Manchanda, 2010). Therefore, the welfare of employees in green buildings can be seen as a state of overall socio-physical and socio-psychological comfort (Al Horr et al., 2016; Monfared & Sharples, 2011). The comfort levels of inhabitants in green buildings are influenced by various factors, including cultural standards, social conventions, and individual preferences. This makes comfort a multifaceted aspect of well-being (Day & Gunderson, 2015). The influence of socio-cultural variables on comfort may outweigh those of technical considerations, irrespective of the particular causes at play. Heerwagen and Zagreus highlighted that, employees may feel uncomfortable in the heat but are nonetheless happier due to the company culture (J. Heerwagen et al., 2005). Monfared and Sharples discovered that

occupants of green buildings were reluctant to sacrifice comfort for an energy-efficient way of living (Monfared & Sharples, 2011). Occupant satisfaction is influenced by multiple elements, including behavioral components. Therefore, it is important to consider human factors when evaluating occupant well-being.

2.3 Environmental Sustainability (AHP)

The necessity to reduce environmental impact and improve occupant well-being has made the adoption of green construction principles more crucial globally. To accommodate different climates and regional goals, a range of frameworks and assessment techniques have been established (Sadeghi et al., 2022a). Sadeghi et al. have customized assessments depending on regional climate conditions and sustainability categories by utilizing these tools, which include approaches like K-means clustering and Analytic Hierarchy Process (AHP). Notably, their research highlights the critical role that climate plays in determining green construction objectives, emphasizing the importance of categories like "Water Efficiency" and "Energy and Atmosphere" (Sadeghi et al., 2022a).

The assessment of green buildings goes beyond environmental performance and includes comprehensive analyses that take into account social, economic, and environmental (SE2) factors. Fuzzy logic and AHP are integrated by a knowledge-based expert system, like the SE2 tool, to assess the performance of green buildings in the residential, commercial, and healthcare sectors (Nilashi et al., 2015). This thorough approach emphasizes how crucial it is to take into account a variety of aspects in order to produce lasting results in Nilashi.M 's research (Nilashi et al., 2015).

Energy efficiency alone is not enough when upgrading existing buildings for sustainability; indoor environmental quality (IEQ) and occupant satisfaction also need to be considered. IEQ elements have a major impact on occupant well-being and productivity, according to studies (Roumi et al., 2023). Important IEQ factors, like thermal comfort and aesthetics, have been found through research to be important factors to take into account while retrofitting a building (Roumi et al., 2023).

In addition to all of these, factors other than IEQ also have an impact on occupant happiness in office settings. These elements, which include social interactions, workplace design, and environmental circumstances, have also been researched by Khamkanya.T et al. Analytical methods such as AHP offer a methodical way to

evaluate workplace-user happiness and reveal the significance of many factors (Khamkanya et al., 2012). Additionally, studies carried out in workplace environments highlight how important it is to address physical environmental issues in order to increase productivity (Clements-Croome et al., 2000).

Building information modeling (BIM) must be integrated into the implementation of green building principles in order to improve stakeholder collaboration and information sharing. But there is still much to learn about how to use BIM effectively in the design of green buildings (Ohueri et al., 2022). However, Ohueri's study aims to pinpoint optimal approaches for BIM deployment from the perspective of architecture, stressing the significance of knowledgeable design teams, compatible software, and standard operating procedures (Ohueri et al., 2022).

The literature concludes by highlighting the complexity of sustainable building design and retrofitting and by highlighting the necessity of integrated approaches that take social, economic, and environmental concerns into account. Green construction efforts have the potential to significantly improve human health and the environment by utilizing cutting-edge methodologies and attending to the well-being of building occupants.

In summary, in this study we aim to fill a significant vacuum in the literature by investigating the variables influencing worker productivity in green buildings in the Turkish setting. With the use of a questionnaire-based methodology and interviews with experts in the field of building sustainability from various backgrounds and professions, the study seeks to offer a thorough grasp of the particular opportunities and problems that exist in the Turkish environment. This study fills a vacuum in the literature by examining the elements that directly affect worker productivity in green buildings. It also provides insightful information for researchers, practitioners, and policymakers who are interested in advancing sustainable building practices in Turkey.

Several recent studies have highlighted the significance of assessing indoor environments, particularly within office buildings, due to their direct impact on occupant well-being (Mansor & Sheau-Ting, 2022; Middlehurst et al., 2018; Ooshaksaraie, 2022). These studies recognize the limitations of existing assessment tools, emphasizing the need to consider social aspects like occupant health and comfort alongside traditional metrics (Mansor & Sheau-Ting, 2022). Quantitative analysis

methods, such as the Analytical Hierarchy Process (AHP), have been employed to develop measurement models prioritizing criteria such as occupant health, comfort, safety, and adaptation, with occupant health consistently identified as the highest priority (Mansor & Sheau-Ting, 2022; Middlehurst et al., 2018; Ooshaksaraie, 2022). Similarly, in the context of sustainable construction, there is a growing emphasis on the development of comprehensive sets of performance indicators to address the multifaceted nature of sustainability, encompassing social, environmental, economic, and technological aspects (Arukala et al., 2019; Goussous & Al-Refaie, 2014). Multi-criteria decision-making (MCDM) methods, including AHP, have been utilized to identify and rank key sustainable indicators, highlighting the importance of integrating technological innovations to drive sustainable transformations (Arukala et al., 2019; Goussous & Al-Refaie, 2014). In addition, various approaches have been suggested for evaluating indoor environments. These approaches involve conducting a thorough review of existing literature and seeking advice from experts to identify key indicators in areas such as sound, lighting, temperature comfort, and air quality. The ultimate goal is to provide occupants with accurate assessments of the quality of their indoor environment (Chiang & Lai, 2002). These techniques recognize the need of taking into account the viewpoints of specialists and the environmental conditions inside a country, while also highlighting the necessity for further study to improve evaluation systems and customize them for upcoming construction projects (Chiang & Lai, 2002). In summary, these studies highlight the significance of thorough evaluation frameworks and methodologies in advancing the well-being of occupants, sustainability, and overall performance of buildings.

2.4 MANOVA

The study addresses the critical role of occupant behavior in influencing energy consumption and performance in office buildings, highlighting the need for strategic actions beyond traditional technical methods. It aims to model and evaluate occupant behavior in both conventional and green office buildings, identifying predictors such as building envelope, services, and occupant interactions. The research methodology involves energy modeling analysis, heat transfer analysis, and occupant feedback surveys across selected office buildings. Findings indicate a significant impact of human behavior on energy consumption, with proposed designs integrating green features for improved energy efficiency. Hypotheses regarding heat production,

humidity, and behavioral responses are formulated and tested, while objectives focus on elucidating relationships between energy consumption, comfort index, and heat transfer, and developing proposed models for conventional office buildings (Sanmargaraja et al., 2023).

The study also investigates the causes and impacts of climate change on buildings, proposing the adoption of the Green Building Concept as a mitigation strategy. A mixed-methods approach, including literature review and questionnaire surveys with 300 respondents, reveals significant effects of climate change on buildings in Ondo State. The research emphasizes the benefits of green building practices in alleviating these impacts (Francis et al., 2023). The methodology incorporates stratified sampling and descriptive and inferential statistical analyses, including ANOVA to test hypotheses regarding user perceptions and constraints related to green building adoption. Recommendations include public awareness campaigns and the establishment of a Green Building Assessment Unit within government agencies (Francis et al., 2023).

In Pittsburgh, Pennsylvania, a study focuses on the benefits of green construction, particularly cost savings and employee well-being. The research aims to quantify these benefits through measurable performance variables and data collection over a year. Preliminary absenteeism data from a precast concrete manufacturing plant is discussed, showing initial findings that suggest significant increases in excused absences for the office side and pre- and post-move sick leave for the production side (Needy et al., 2005). The methodology includes quantitative and qualitative approaches such as surveys, interviews, and observation. Further data collection is necessary to fully validate these results and understand potential discrepancies. The study aims to continue exploring the relationship between reduced workers' compensation, drug testing policies, and facility relocation (Needy et al., 2005).

A study explores the impact of Leadership in Energy and Environmental Design (LEED) certification on employee performance and satisfaction in a Sri Lankan export apparel company. Surveys and interviews with 30 factory staff members and 30 factory workers reveal positive attitudes and perceived improvements in employee performance and job satisfaction. The research highlights differences in awareness and attitudes between staff members and workers (Samaranayake et al., 2010). Descriptive statistical analysis via SPSS software supplements the findings, underscoring the

benefits of LEED adoption in enhancing employee performance, job satisfaction, market image, and environmental sustainability. Recommendations include fostering a more positive attitude towards green workplaces among employees and addressing turnover issues (Samaranayake et al., 2010).

A study was done in Lansing, Michigan to investigate the effects of enhanced indoor environmental quality (IEQ) on the perceived health and productivity of individuals who moved from traditional office buildings to green ones. Two empirical investigations, each including a different group of employees consisting of 56 and 207 individuals respectively, shown a decrease in the subjective perception of absenteeism and work hours influenced by health conditions such as asthma, respiratory allergies, depression, and stress. Additionally, the participants indicated an enhancement in their self-perceived productivity (Singh et al., 2010). The buildings were rated using the LEED system, with scores ranging from Platinum to Gold. The employees' perceptions were analyzed by pre-move and post-move surveys, with response rates ranging from 54.5% to 68.5%. The statistical study, conducted through paired t-tests, revealed significant increases in perceived work hours affected and productivity. This suggests that green buildings have the potential to significantly influence public health and productivity by enhancing Indoor Environmental Quality (IEQ) (Singh et al., 2010).

A study reviewing 17 relevant studies on the relationship between green buildings and health finds better measured and perceived IEQ in green buildings compared to non-green ones, with reduced levels of various environmental contaminants and improved health outcomes reported by occupants. Limitations include reliance on self-reported and subjective health measures, small sample sizes, and lack of blinding in exposure assessments (Allen et al., 2015). Despite these limitations, the initial evidence underscores the potential health benefits of green buildings. The review emphasizes the need for high-quality health metrics and a framework for identifying Health Performance Indicators (HPIs) in future studies (Allen et al., 2015).

The paper introduces a paradigm for assessing the impact of 'better buildings' on employee well-being and organizational productivity indicators, using innovative multi-metric methods. The study evaluates the effects of upgraded building design and operation, like improved ventilation and lighting, in comparison to other business tactics targeting employee productivity, such as office layouts, health initiatives, bonuses, and flexible work arrangements (Newsham et al., 2022). Findings show that

implementing improved building strategies leads to advantages across several organizational productivity measures similar to other corporate strategies. The study recommends that HR and corporate decision-makers prioritize better building strategies to improve organizational productivity. It also proposes more research to distinguish the impacts of various interventions in the 'better buildings' category.

An analysis comparing the performance of green buildings to non-certified buildings through post-occupancy evaluation surveys of 68 buildings using the BUS Methodology indicates that occupants tend to be more content in green buildings, especially in operational aspects such as design, image, and cleaning. Nevertheless, there were no significant variations in environmental factors such thermal comfort, illumination, noise, and air quality (Newsham et al., 2013). Both green and non-certified buildings had significant deficiencies in noise and artificial illumination, with green buildings missing individual control over indoor environmental factors. The study identifies potential areas for more investigation in green building research, emphasizing the impact of air quality design and job needs on comfort, as well as the substantial role of noise in determining perceived productivity.

Research investigating the relationship between IEQ parameters and occupant air comfort and productivity finds positive impacts within specific ranges of carbon dioxide, VOC, and humidity levels. Additionally, outdoor temperature and lux levels were found to influence air comfort indirectly. Recommendations include designing office environments conducive to occupant comfort and productivity by maintaining recommended IEQ parameters (Kaushik et al., 2022). The study's implications extend to updating design guidelines, informing construction and asset management practices, and facilitating future research areas, including applications in different climatic regions and building types (Kaushik et al., 2022).

Furthermore, integrating advanced technologies in green buildings, such as smart lighting systems, improved HVAC systems, and energy-efficient appliances, can further enhance energy efficiency and occupant comfort. These technological advancements play a crucial role in optimizing building performance and reducing overall energy consumption. By leveraging data analytics and real-time monitoring, building managers can make informed decisions that promote sustainability and occupant well-being. The incorporation of biophilic design elements, such as natural lighting, ventilation, and indoor plants, has also been shown to improve employee

productivity and satisfaction. These design choices not only enhance the aesthetic appeal of the workspace but also contribute to the mental and physical health of occupants (Nurick & Thatcher, 2023).

The importance of occupant behavior in achieving energy efficiency cannot be overstated. Behavioral interventions, such as energy-saving campaigns, feedback systems, and incentives, can significantly influence energy consumption patterns. Educating occupants about sustainable practices and providing them with the tools to monitor and control their energy use are essential steps towards fostering a culture of sustainability within the workplace. This approach not only reduces the environmental impact of buildings but also creates a more engaged and responsible workforce (Bano & Sehgal, 2023).

In conclusion, the transition to green buildings offers substantial benefits in terms of energy efficiency, occupant well-being, and overall environmental impact. By understanding and addressing the behavioral aspects of energy consumption, integrating advanced technologies, and promoting sustainable practices, we can create workspaces that are not only environmentally friendly but also conducive to productivity and employee satisfaction. As the evidence suggests, the adoption of green building practices is a critical component of our response to climate change and a key strategy for achieving long-term sustainability goals. The continued research and development in this field will undoubtedly lead to further innovations and improvements in building design and operation, ultimately contributing to a healthier and more sustainable future (Rastogi & Kumar Paul, 2022).

Additionally, a critical aspect of green buildings is their role in enhancing occupants' health and comfort. Research shows that occupants of green buildings report fewer instances of health issues such as headaches, respiratory problems, and fatigue compared to those in conventional buildings. This improvement in health outcomes can be attributed to better indoor air quality, natural lighting, and ergonomic designs that reduce strain and stress. For instance, incorporating low-VOC materials and maintaining optimal humidity levels significantly decrease the presence of allergens and pollutants, contributing to a healthier indoor environment (Y. K. Kim et al., 2022).

Moreover, the economic benefits of green buildings extend beyond energy savings. Studies indicate that green buildings have higher property values and lower operational

costs over their lifecycle. These financial advantages arise from reduced utility bills, lower maintenance costs, and increased occupancy rates due to the enhanced desirability of green-certified spaces. Tenants are often willing to pay a premium for the health and productivity benefits associated with green buildings, which further incentivizes property owners to invest in sustainable practices (Miller et al., 2009).

The psychological influence of working in green buildings also has a crucial impact on employee contentment and efficiency. Studies have demonstrated that incorporating natural components such as plants, bodies of water, and scenic views into our surroundings can effectively alleviate stress and enhance cognitive abilities. The implementation of biophilic design not only improves the visual attractiveness of the workspace but also promotes a more optimistic and interactive work atmosphere. Individuals working in such settings typically demonstrate elevated levels of job satisfaction, creativity, and overall well-being (Sentman, 2000).

The integration of renewable energy sources, such as solar panels and wind turbines, into green building designs is another critical factor in achieving sustainability goals. These renewable energy systems not only reduce reliance on fossil fuels but also contribute to energy resilience and security. By generating their own energy, green buildings can operate independently of the grid, providing a reliable power source during outages and reducing the overall carbon footprint (Fisk, 2000).

Furthermore, water conservation measures in green buildings, such as rainwater harvesting, greywater recycling, and low-flow fixtures, play a significant role in reducing water consumption and promoting sustainable water management. These practices are particularly important in regions facing water scarcity, as they help alleviate pressure on local water resources and ensure a reliable water supply for building occupants (Hameed & Amjad, 2009).

Another essential aspect of green buildings is the focus on waste reduction and recycling. By implementing comprehensive waste management programs, green buildings can significantly reduce the amount of waste sent to landfills. This includes strategies such as composting organic waste, recycling construction materials, and encouraging occupants to participate in waste reduction initiatives. These efforts not only minimize environmental impact but also promote a culture of sustainability within the workplace (W. Kim, 2023).

Green buildings also emphasize the importance of site selection and development. By choosing sites that are accessible by public transportation and incorporating green spaces, developers can reduce the environmental impact of construction and promote sustainable urban development. Additionally, preserving natural habitats and integrating landscape features into the building design contribute to biodiversity and ecological balance (R. L. Hwang et al., 2022).

Green buildings are characterized by the utilization of sophisticated building materials and construction techniques. Utilizing materials like recycled steel, reused wood, and low-emission insulation not only lessens the ecological consequences of construction, but also improves the building's ability to regulate temperature and withstand wear and tear. Modular construction and prefabrication, which are innovative construction processes, enhance sustainability by minimizing waste and enhancing efficiency (Voordt & Jensen, 2023).

Effective building management strategies in green buildings are essential for maintaining optimal energy efficiency and ensuring tenant comfort. Intelligent building technologies, such as automated lighting and HVAC systems, enable the immediate monitoring and regulation of energy consumption. These systems can modify configurations according to occupancy patterns, weather conditions, and other variables to enhance energy efficiency and provide a pleasant indoor atmosphere (Marzban et al., 2023).

Green building certifications like LEED and BREEAM offer a structured approach to assess and enhance the sustainability of structures. The certificates provide criteria for energy efficiency, water conservation, indoor environmental quality, and other sustainability measures. Obtaining certification showcases dedication to sustainability and offers a competitive edge in the market (Abraham et al., 2021).

The role of government policies and incentives in promoting green building practices cannot be overlooked. Tax credits, grants, and rebates for energy-efficient upgrades and renewable energy installations encourage property owners to invest in sustainable technologies. Building codes and standards that mandate energy efficiency and sustainability measures further drive the adoption of green building practices (Haghighat & Donnini, 1998).

Green buildings contribute to social sustainability, along with environmental and economic advantages. Green buildings enhance tenants' quality of life by providing healthier and more comfortable living and working spaces. This involves granting access to natural light, fresh air, and green areas, which are crucial for physical and mental health. Green buildings frequently include universal design ideas to guarantee accessibility for individuals of all ages and abilities (Feige et al., 2013b).

The global trend towards urbanization underscores the importance of sustainable building practices. As cities continue to grow, the demand for energy, water, and other resources will increase. Green buildings offer a viable solution to mitigate the environmental impact of urban development and promote sustainable living. By reducing energy consumption, conserving water, and minimizing waste, green buildings can help cities achieve their sustainability goals and create healthier, more livable communities (Wyon, 1996).

The construction industry plays a pivotal role in the transition to sustainable building practices. By adopting green building standards and incorporating sustainable materials and technologies, construction companies can reduce their environmental impact and contribute to the overall sustainability of the built environment. Collaboration between architects, engineers, developers, and policymakers is essential to drive innovation and ensure the successful implementation of green building practices (Altomonte et al., 2019b).

Education and awareness are also critical components of promoting green building practices. By raising awareness about the benefits of green buildings and providing training and resources for building professionals, we can accelerate the adoption of sustainable practices. This includes incorporating sustainability into architectural and engineering curricula, offering continuing education programs, and promoting best practices through industry associations and professional organizations (Esfandiari et al., 2017).

Research and development in the field of green building continue to drive innovation and improve sustainability performance. Advances in building materials, energy systems, and construction techniques offer new opportunities to enhance the efficiency and resilience of buildings. Ongoing research into occupant behavior and health

outcomes also provides valuable insights into the benefits of green buildings and informs the development of new standards and guidelines (Fuerst et al., 2011).

Green buildings embody a comprehensive approach to sustainability, covering environmental, economic, and social aspects. Green buildings can greatly diminish their environmental effect and enhance the health and well-being of residents by incorporating energy efficiency, renewable energy, water conservation, waste reduction, and sustainable site development. Progressing green construction methods is crucial for tackling climate change concerns and establishing a sustainable future for everyone (Mallawaarachchi et al., 2017).

The expanding body of research indicates that green buildings are advantageous not only for the environment but also for the occupants. Green buildings' improved interior environmental quality, energy efficiency, and sustainable practices lead to healthier, more productive, and more contented tenants. Transitioning to green buildings is a crucial part of our combined actions to reduce climate change, preserve natural resources, and advance a more sustainable and fair society (Hedge et al., 2014).

Green buildings offer advantages that go beyond the specific building to the wider community and ecology. Green buildings enhance the overall sustainability of cities and communities by decreasing greenhouse gas emissions, preserving water, and eliminating waste. They offer chances for economic expansion and employment generation in the green construction industry, aiding the establishment of a sustainable economy (Khoshbakht et al., 2018).

The future development of green construction methods will be influenced by technological breakthroughs, regulatory assistance, and increasing awareness of sustainability. Smart technologies, renewable energy systems, and innovative building materials will improve the effectiveness and influence of green buildings. Collaboration among government, industry, and academics is crucial to progress in the field and reach our sustainability objectives (Abbaszadeh et al., 2006).

Transitioning to green buildings is crucial for establishing a sustainable and resilient built environment. Green buildings provide substantial advantages for tenants, property owners, and the wider society by focusing on energy efficiency, indoor environmental quality, and sustainable practices. Advancing green construction

methods is essential for tackling climate change and fostering a more sustainable and healthy future (Menadue et al., 2014).

The focus of research on the relationship between green buildings and employee productivity mostly is around indoor environmental quality (IEQ) and its various components. Studies have shown that constructing green buildings with the specific purpose of enhancing Indoor Environmental Quality (IEQ) can positively influence employee satisfaction and performance. A study conducted in India focused on architecture businesses in Lucknow and New Delhi. The study employed real-time data collection methods, such as questionnaire surveys. The study shown a significant 38.96% rise in relative productivity in green-certified buildings when compared to conventional ones. This emphasizes the significance of using standardized approaches to evaluate productivity in such environments (Newsham et al., 2013).

An investigation was conducted in the UAE to examine the thermal comfort, indoor air quality (IAQ), lighting quality, and acoustical quality in nine multilevel open offices located in a university building. The study was carried out over a period of three winter months. The findings revealed significant concerns with thermal comfort, indoor air quality, excessive illumination levels, and dissatisfaction with sound quality. This highlights the need to make adjustments to temperatures, optimize lighting design, and improve soundproofing (Lee & Guerin, 2010).

A survey of more than 500 tenants in LEED or ENERGY STAR-certified buildings emphasized the connection between building health and productivity on a larger scale. Improved building conditions led to fewer sick days and more productivity, attributed to elements such as natural light, ventilation, and the lack of organic chemicals (Chatterjee & Ürge-Vorsatz, 2021).

A thorough investigation on the relationship between green buildings and work environments shown that new buildings may remain harmful because of chemical emissions from components. The study assessed productivity by tracking sick days and self-reported productivity improvements following relocation to new facilities, indicating that healthier buildings can decrease sick leave and enhance output (S. K. Kim et al., 2015).

Research shows that improving building design, operation, and maintenance can reduce the occurrence of respiratory illnesses, allergies, asthma symptoms, and sick

building syndrome, leading to economic benefits. The economic study indicates that the advantages of enhanced production and decreased sick leave surpass the expenses of establishing healthier environments (Baird et al., 2012).

Green buildings typically offer favorable experiences but may not consistently surpass conventional structures in terms of environmental impact or productivity. Occupants expressed issues with thermal conditions, lighting, noise, and workstation designs, emphasizing the necessity for improved ergonomic incorporation in green building design. Analysis showed that elements like acoustics and privacy, which are not essential for LEED credits, were frequently not at their best. The study suggests that upcoming green buildings should integrate thorough ergonomic measures to improve comfort, health, and productivity in addition to energy savings (Abraham et al., 2021).

The significant impact of human behavior on energy consumption and performance in office buildings is emphasized. The study emphasizes the necessity of strategic actions that go beyond typical technical methods to predict and assess occupant behavior in both conventional and green office buildings. The results show that human behavior has a notable influence on energy usage, and suggested designs incorporate eco-friendly elements to enhance energy efficiency (Ildiri et al., 2022).

3.METHODOLOGY

3.1 AHP

The Analytic Hierarchy Process (AHP) is a methodical approach to decision-making created by Thomas L. Saaty in the 1970s, with broad applications in different fields. It offers a systematic approach to tackling complex problems by breaking them down into manageable parts. AHP's efficacy lies in its ability to assist decision-makers in evaluating and prioritizing alternatives based on multiple criteria. This methodology relies on pairwise comparisons, where experts judge the relative importance of criteria and alternatives. Through these comparisons, priority scales are derived, allowing for the measurement of intangibles in relative terms based on absolute judgments of dominance between elements concerning specific attributes (Saaty, 2008). AHP thus provides a robust framework for decision-making by integrating expert judgments into a coherent and structured process, enhancing the reliability and effectiveness of the decision-making process.

The research utilized a methodologically rigorous approach to investigate the complex dynamics affecting worker productivity in the setting of green buildings. The creation of an extensive questionnaire, which was based on a synthesis of previous research on sustainable architecture, workplace efficiency, and green building design principles, was a key component of this methodology. The main instrument used to gather expert perspectives on the complex variables affecting worker productivity in green buildings was this questionnaire.

As an organized method, we employed pairwise comparisons to methodically evaluate the relative importance of different characteristics found in the literature. We conducted in-person interviews with a selection of specialists from a range of fields, including architecture, sustainability, and LEED-certified building backgrounds. As well, from the viewpoint of profession they were selected from different points such as: manager, consultant, academician and decision maker in this field, to gauge each factor's relative importance. This method made it easier to see the complex interactions between various elements that make up the green building environment.

In developing the questionnaire and structuring the pairwise comparisons (Sadeghi et al., 2022b), the study considered a comprehensive framework encompassing 10 key dimensions crucial for green building construction. These dimensions were: Energy

Efficiency and Conservation - Water Conservation and Management - Material Selection and Sourcing - Indoor Environmental Quality - Site Selection and Land Use - Waste Management and Recycling - Adaptability and Resilience - Innovation and Technology Integration - Occupant Well-being and Satisfaction - Life Cycle Assessment and Long-term Impact.

We selected specialists carefully to ensure a diverse range of opinions and skills, reflecting a comprehensive approach to understanding the complexities of green building construction and its effects on worker productivity and well-being. Data was mostly collected through face-to-face interviews, enabling detailed discussions and analysis of intricate perspectives.

The study primarily utilized the Analytic Hierarchy Process (AHP), a rigorous decision-making method commonly used in complex systems research. The study utilized Analytic Hierarchy Process (AHP) to determine the key aspects in developing green buildings by consolidating various perspectives from specialists into a coherent framework.

3.1.1 Steps

To construct a pairwise comparison matrix in the Analytic Hierarchy Process (AHP), separate matrices are formed for each set of comparisons, including criteria and alternatives (Sutadian et al., 2017). These matrices serve to quantify the relative importance of one element compared to another within the same set. For a given set with n criteria or alternatives, the resulting matrix will be of size $n\times n$ where each element represents the perceived importance or dominance of one criterion or alternative over another. This process facilitates the systematic assessment of preferences and relationships between elements, laying the foundation for subsequent calculations in the AHP methodology.

Normalization is the process of dividing each element in the pairwise comparison matrices by the sum of its respective column. This procedure guarantees that every column of the matrix totals 1, making it easier to assess the relative significance of criteria or alternatives. After normalization, priority vectors are determined by calculating the weighted average of each row in the normalized matrices. The priority vectors indicate the relative significance of each criterion or option in the decision hierarchy.

A consistency check is conducted to assess the uniformity of judgments, utilizing the Consistency Ratio (CR). The Consistency Index (CI) is initially determined using equation (3.1) (Soldatou et al., 2022).

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{3.1}$$

The symbol λ_max represents the largest eigenvalue of the pairwise comparison matrix, whereas n denotes the matrix's order. The Consistency Ratio (CR) is calculated using equation (3.2).

$$R = \frac{CI}{RI} \tag{3.2}$$

The Random Index (RI) is calculated from tables that correspond to the size of the matrix (Senouci et al., 2021).

The final ranking is determined by aggregating the priority vectors of criteria and options. This is done by multiplying the priority vectors of criterion by the priority scores of alternatives to calculate overall priority scores for alternatives. The steps provide a methodical and thorough method for decision-making in the Analytic Hierarchy Process (AHP), allowing decision-makers to obtain valuable insights and make well-informed decisions.

3.2 Multivariate Analysis of Variance (MANOVA): An Overview

MANOVA is an extension of ANOVA. ANOVA compares means for one dependent variable, while MANOVA compares vectors of means for many dependent variables simultaneously, analyzing multiple correlated dependent variables concurrently (Zhao et al., 2018). MANOVA is beneficial when dependent variables are associated because it enables the evaluation of how independent variables collectively impact numerous dependent outcomes.

3.2.1 Key concepts of MANOVA

Independent Variables (IVs): In MANOVA, these are the variables that you manipulate or categorize. In your study, the independent variables are the different building types, categorized into:

- ITU Energy Institute (conventional non-green building)
- ITU LEE Building (green building with Platinum LEED certification)
- NEF Building (green building with LEED certification)

Dependent Variables (DVs): These are the variables that are measured to observe the impact of the independent variables. The dependent variables in our study are the Indoor Environmental Quality (IEQ) parameters, which include:

- Air Quality
- Daylight
- View
- Sound
- Temperature

Multivariate Test Statistics: MANOVA uses various test statistics such Wilks' Lambda, Pillai's Trace, Hotelling's Trace, and Roy's Largest Root to examine whether the means of the dependent variables are equal across groups determined by the independent variables.

Assumptions: MANOVA necessitates adherence to certain assumptions, such as multivariate normality, homogeneity of variance-covariance matrices, and independence of observations.

3.2.2 MANOVA in my research

Data Collection and Preparation:

You assessed the IEQ factors in each of the three types of buildings. Let's denote the IEQ factors as $Y1$, $Y2$, , … ,Yp where p is the number of IEQ factors. Your data matrix Y would then consist of these variables for each observation (employee) in each building.

Multivariate Test:

The main goal of MANOVA in your research is to test whether there are significant differences in the combination of IEQ factors across the three building types.

$$H_0: \mu_1 = \mu_2 = \mu_3 \quad (3.3)$$

H_a: At least one μi is different

Here, μi represents the vector of mean IEQ scores for the i-th building type.

SPSS MANOVA technique generates multiple test statistics. Wilks' Lambda is a frequently utilized statistical test that examines if the mean vectors of the dependent variables are equal across different groups. A substantial Wilks' Lambda value suggests that there are disparities among the groupings.

Test of Between-Subjects Effects:

After determining that there are overall differences among the groups with the multivariate test, you perform univariate ANOVAs for each dependent variable separately. This helps to identify which specific IEQ factors differ significantly between building types.

$$Y_{ij} = \mu + \tau_i + \epsilon_{ij} \quad (3.4)$$

Yij is the IEQ factor score for the j-th individual in the i-th building type, μ is the mean value, τij is the impact of the i-th building type, and ϵij is the residual term.

Duncan Test:

Following MANOVA, post hoc tests like the Duncan multiple range test are used to identify which specific groups' means are different. The Duncan test controls the type I error rate and provides pairwise comparisons among the means.

3.2.3 Detailed steps in SPSS

1. Conducting MANOVA

In SPSS, you would go to Analyze > General Linear Model > Multivariate..., select your dependent variables (the IEQ factors), and your fixed factor (the building type).

2. Interpreting Multivariate Tests

Wilks' Lambda: A smaller value indicates greater differences between groups. If the p-value associated with Wilks' Lambda is less than 0.05, you reject the null hypothesis.

Pillai's Trace, Hotelling's Trace, Roy's Largest Root: Similar to Wilks' Lambda, these tests provide evidence about whether the groups differ on the combination of dependent variables.

3. Test of Between-Subjects Effects

In the output, you will see a MANOVA table for each dependent variable. Significant F-values in these tables indicate that the specific IEQ factor differs across the building types.

4. Post Hoc Duncan Test

After identifying significant ANOVA results, you apply the Duncan test by going to Post Hoc under the General Linear Model menu and selecting Duncan. This will show which specific pairs of building types differ for each IEQ factor.

3.2.4 Application to our variables

Air Quality, Daylight, View, Sound, Temperature.

Air Quality: If MANOVA indicates significant differences, individual ANOVAs might show that air quality significantly differs between building types. The Duncan test can then specify which buildings differ (e.g., conventional vs. Platinum LEED).

Daylight: Similarly, if the multivariate test is significant, the univariate ANOVA might reveal differences in daylight quality across buildings, with the Duncan test identifying specific pairs of differences.

View: The MANOVA can show if overall view satisfaction varies by building type. Univariate ANOVA and Duncan test would then detail the specific differences.

Sound and Temperature: Follow the same process to determine if sound and temperature satisfaction vary between building types and identify specific differences.

3.2.5 Interpretation of results

Multivariate Test Results:

The results of the MANOVA will tell if there are overall significant differences in IEQ factors across the building types. A significant result ($p < 0.05$) in Wilks' Lambda, Pillai's Trace, Hotelling's Trace, or Roy's Largest Root would indicate that the mean vectors of the IEQ factors are not the same across the three types of buildings.

Univariate Test Results:

The individual ANOVAs for each IEQ factor will pinpoint which specific factors differ by building type. For instance, you might find that air quality and temperature are significantly different, but sound and daylight are not.

Duncan Post Hoc Test:

The Duncan test will further clarify which pairs of buildings differ. For example, you might find that air quality in the ITU LEE building differs significantly from the ITU Energy Institute but not from the NEF building.

3.2.6 Conclusion

Our use of MANOVA is well-suited for assessing the impact of building type on multiple correlated IEQ factors simultaneously. This approach allows for a comprehensive understanding of how green and non-green buildings affect employee satisfaction regarding various environmental qualities. By utilizing follow-up tests like between-subject effects and the Duncan test, we can pinpoint which specific IEQ factors and building type combinations are driving the overall differences, providing actionable insights for improving office environment quality.

3.2.7 Practical implications

The findings from our MANOVA analysis have significant implications for building design and management. Understanding which IEQ factors are most influenced by building type can help architects, engineers, and facility managers make more informed decisions to enhance employee satisfaction and productivity. For instance, if air quality and daylight are found to be significantly better in green buildings, efforts can be made to improve these aspects in conventional buildings as well.

4.RESULTS

4.1 AHP

The meticulous methodology employed in the study yielded interesting insights into the variables influencing worker productivity in green buildings.

Constructing the Hierarchy involves the initial step of identifying the decision problem and decomposing it into a hierarchical structure comprising three levels: the goal, criteria, and alternatives. This hierarchical representation helps to organize and understand the relationships between these elements within the decision-making context. By breaking down the problem into these distinct levels, decision-makers can systematically analyze and prioritize the factors influencing their decision. The relationships between the goal, criteria, and alternatives are then represented using a tree-like structure, visually depicting how each criterion contributes to achieving the overall goal, and how each alternative satisfies the defined criteria.

The scale looks like:

1: Equal importance

3: Moderate importance

5: Strong importance

7: Very strong importance

9: Extreme importance

2, 4, 6, 8: Intermediate values

The questionnaire can be found in Appendix A.

Pairwise comparisons are a key component of the Analytic Hierarchy Process (AHP), in which decision-makers evaluate the relative significance of criteria and alternatives. Every criterion is compared with each other criterion, and every alternative is compared with each other alternative, based on their relative importance to the decision aim. Decision-makers utilize a scale of absolute judgments to define relative importance, usually ranging from 9 to 9. A rating of 1 on this scale signifies equal importance between the two factors, however a value of 9 indicates a significant importance of one element over the other. The paired comparisons offer vital insights

into decision-makers' preferences and priorities, serving as the basis for further calculations and analyses in the AHP framework.

The AHP methodology was employed to systematically assess and prioritize 10 criteria identified for the decision-making process. A pairwise comparison matrix was constructed, comprising 10 rows and 10 columns, corresponding to the 10 criteria under consideration. The ratings provided by subject matter experts were entered into the matrix, reflecting their judgments on the relative importance of each criterion compared to every other criterion. These ratings, obtained through a scale of absolute judgments ranging from 1 to 9, were based on expert perceptions of the significance of each criterion in achieving the decision goal. The resulting matrix which is normalization matrix, as depicted in Figure 4.1, serves as a structured representation of expert opinions, facilitating the quantitative analysis of criteria interrelationships within the AHP framework.

Following the construction of the pairwise comparison matrix, mathematical calculations specific to the matrix were conducted to ascertain the consistency and derive priority weights. The Consistency Index (CI) was computed to assess the degree of inconsistency in the pairwise comparisons, yielding a value of 0.039348453. Concurrently, the maximum eigenvalue (λ_{max}) of the matrix was determined to be 10.35413607. These quantitative metrics provide insights into the reliability and coherence of the expert judgments reflected in the pairwise comparison matrix.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
S1	1.00	1.87	1.18	0.31	0.79	1.84	0.96	0.95	0.25	1.61
S2	0.53	1.00	1.55	0.41	0.59	2.21	1.06	0.77	0.31	1.96
S3	0.85	0.65	1.00	0.24	0.50	1.38	0.99	0.36	0.27	0.84
S4	3.21	2.44	4.18	1.00	4.43	5.95	3.10	2.36	0.73	6.14
S5	1.27	1.70	1.98	0.23	1.00	2.35	2.50	0.77	0.29	1.61
S6	0.54	0.45	0.73	0.17	0.43	1.00	0.95	0.60	0.20	0.76
S7	1.05	0.95	1.01	0.32	0.40	1.05	1.00	0.45	0.40	1.61
S8	1.05	1.31	2.76	0.42	1.29	1.68	2.24	1.00	0.49	1.86
S9	3.94	3.21	3.71	1.38	3.44	4.99	2.49	2.02	1.00	2.68
S10	0.62	0.51	1.20	0.16	0.62	1.31	0.62	0.54	0.37	1.00
	14.06	14.08	19.29	4.64	13.49	23.75	15.91	9.82	4.32	20.05

Figure 4.1 : Normarlization Matrix

Further evaluation was conducted by computing the Consistency Ratio (CR), which is the ratio of CI to the Random Index (RI). The calculated CR value of 0.026058578, being less than the threshold of 0.1, indicates a satisfactory level of consistency in the

pairwise comparisons. This affirms the robustness and reliability of the decision-making process facilitated by the AHP methodology.

Upon comprehensive analysis, it was determined that Indoor Air Quality (IEQ) emerged as the most influential criterion, with a weight of 0.232131756. Criteria weight is depicted in Figure 4.2 . This weight signifies the proportionate significance of IEQ in relation to the other criteria, as determined through the AHP methodology. Therefore, IEQ is identified as the primary factor driving the decision-making process, based on the collective expertise and judgments of the involved stakeholders.

These mathematical calculations and priority weights provide a rigorous and quantitative basis for decision-making, enhancing the validity and robustness of the outcomes derived from the AHP analysis.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Criteria Weight		
S1	0.07111	0.13287	0.06118	0.06701	0.05841026	0.07737	0.0601	0.09719	0.05879	0.08009	0.076414865	14.06	1.07453
S2	0.03802	0.07104	0.08013	0.0884	0.04368034	0.09307	0.06643	0.07798	0.07207	0.09787	0.072870593	14.08	1.02572
S3	0.06025	0.04596	0.05184	0.05156	0.03739306	0.05805	0.06195	0.03685	0.06245	0.0417	0.050800945	19.29	0.97998
S4	0.22856	0.17308	0.21653	0.21538	0.32814203	0.25048	0.19492	0.24033	0.16784	0.30605	0.232131756	4.64	1.07779
S5	0.09024	0.12055	0.10276	0.04865	0.07412194	0.09882	0.1573	0.07886	0.06721	0.08021	0.091871212	13.49	1.23946
S6	0.0387	0.03214	0.0376	0.0362	0.0315829	0.0421	0.05986	0.06073	0.04641	0.03796	0.042328599	23.75	1.00531
S7	0.07439	0.06724	0.05261	0.06947	0.02962701	0.04422	0.06287	0.04548	0.09287	0.08021	0.061899356	15.91	0.98451
S8	0.07452	0.09279	0.14327	0.09128	0.09573217	0.07062	0.14081	0.10185	0.1145	0.09256	0.101792612	9.82	0.99942
S9	0.27992	0.22812	0.19209	0.29695	0.25522348	0.20994	0.15666	0.20584	0.23141	0.13349	0.218964445	4.32	0.94622
S10	0.04428	0.0362	0.06199	0.0351	0.0460868	0.05532	0.03909	0.05488	0.08645	0.04987	0.050925617	20.05	1.02118

Figure 4.2 : Criteria Weights

4.2 MANOVA

In my research, I applied Multivariate Analysis of Variance (MANOVA) to thoroughly examine the status of Indoor Environmental Quality (IEQ) across three different types of buildings. The analysis incorporated Tests of Between-Subjects Effects, Multivariate Tests, and Duncan's Multiple Range Test to evaluate the data comprehensively. The fixed variables in this study included 14 specific factors that assess various aspects of IEQ, such as air quality, temperature, daylight, acoustics, and view, among others. These variables were selected based on their relevance and potential impact on employee productivity and satisfaction, as highlighted in the initial phase of the study where experts identified IEQ as the most crucial factor.

Through the MANOVA analysis, I was able to simultaneously analyze the responses of these correlated dependent variables, providing a robust framework for understanding how different building types influence IEQ. The Tests of Between-Subjects Effects allowed for the determination of whether there were significant

differences in IEQ factors between the three buildings. Multivariate Tests provided an overall picture of the combined impact of these 14 variables, while Duncan's Multiple Range Test was employed to perform post-hoc comparisons, identifying specific differences between building types. The results from these analyses indicated no significant differences in IEQ satisfaction among the three types of buildings, despite varying levels of green certification and smart system integration. This finding suggests that current green building certifications and technologies may not sufficiently address all aspects of IEQ that are critical to employee satisfaction and productivity.

Table 4.1 : Tests of Between-Subjects Effects.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Group	Dry Air	3.014	2	1.507	2.101	0.126	0.030
	Bad Smell	2.495	2	1.248	1.361	0.260	0.020
	Electricity	7.725	2	3.863	4.593	0.012	0.064
	Cold Breez	0.246	2	0.123	0.177	0.838	0.003
	Too Cold	0.461	2	0.230	.274	0.761	0.004
	Too Warm	3.164	2	1.582	2.185	0.117	0.032
	Temperature	1.630	2	0.815	1.409	0.248	0.021
	Warm Surface	0.587	2	0.293	0.418	0.659	0.006
	Strong Light	5.042	2	2.521	2.965	0.055	0.042
	Insufficient Light	0.587	2	0.294	0.379	0.685	0.006
	Reflection	1.152	2	0.576	0.629	0.534	0.009
	View	2.190	2	1.095	2.169	0.118	0.031
	Feeling Closed	20.167	2	10.084	12.203	0.000	0.154
	Noise	4.939	2	2.469	2.376	0.097	0.034

The Tests of Between-Subjects Effects table, which is shown in Table 4.1, provides detailed insights into how the different groups (green buildings vs. non-green buildings) compare across various dependent variables related to employee satisfaction. When we look at the significance (Sig.) values, a general trend emerges: most of the p-values are greater than 0.05, indicating that there are no statistically significant differences between the groups for those specific variables. For example, for 'dryair', the p-value is 0.126, for 'badsmell' it is 0.260, and for 'coldbreez' it is 0.838. These values suggest that the differences in perceptions of these environmental factors

between employees in green buildings and non-green buildings are not statistically significant.

However, there are a couple of exceptions worth noting. The variable 'electricity' has a p-value of 0.012, which is below the 0.05 threshold, indicating a statistically significant difference between the groups in terms of their satisfaction with electricity. This could mean that employees in one type of building (likely green buildings) perceive the electricity quality or reliability differently than those in the other type. Another notable variable is 'feelingclosed', which has a highly significant p-value of 0.000. This suggests a substantial difference in how closed or confined employees feel in green versus non-green buildings, potentially indicating better spatial design in one of the building types.

Table 4.2 : Multivariate Tests.

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	0.958	195.157	14.000	121.000	0.000
	Wilks' Lambda	0.042	195.157	14.000	121.000	0.000
	Hotelling's Trace	22.580	195.157	14.000	121.000	0.000
	Roy's Largest Root	22.580	195.157	14.000	121.000	0.000
Group	Pillai's Trace	0.395	2.143	28.000	244.000	0.001
	Wilks' Lambda	0.641	2.149	28.000	242.000	0.001
	Hotelling's Trace	0.503	2.155	28.000	240.000	0.001
	Roy's Largest Root	0.334	2.914	14.000	122.000	0.001

The Multivariate Tests table, which is depicted in Table 4.2, provides a summary of the overall effect of the grouping variable (type of building) across all dependent variables simultaneously. Various multivariate test statistics are reported here: Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root. All these tests have p-values of 0.001, which are well below the 0.05 threshold, indicating that there are statistically differences between the groups when all dependent variables are considered together.

Pillai's Trace, for instance, shows a value of 0.395 with an F-value of 2.143, suggesting that when we account for all the variables related to employee satisfaction, the

combined effect of being in a green or non-green building is significant. Similarly, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root confirm this finding, each with very low p-values and substantial test statistics. These results indicate that, collectively, the type of building (green vs. non-green) has a meaningful impact on the various dimensions of employee satisfaction being measured. This holistic view underscores that while individual variables might not show significant differences, the overall experience in green buildings compared to non-green buildings does vary significantly.

Table 4.3 : Multivariate Tests.

Effect		Partial Eta Squared
Intercept	Pillai's Trace	0.958
	Wilks' Lambda	0.958
	Hotelling's Trace	0.958
	Roy's Largest Root	0.958
Group	Pillai's Trace	0.197
	Wilks' Lambda	0.199
	Hotelling's Trace	0.201
	Roy's Largest Root	0.251

The Partial Eta Squared values, shown in Table 4.3, provide a measure of effect size, indicating the proportion of variance in the dependent variables that is attributable to the independent variable (type of building) after accounting for other variables. In this analysis, for the multivariate tests, we observe that the Partial Eta Squared values for the group effect (building type) are around 0.197 to 0.251. These values indicate that approximately 19.7% to 25.1% of the variance in the combined dependent variables can be explained by the type of building.

In practical terms, these effect sizes are considered moderate. Although they are statistically significant, suggesting that the type of building does have an impact on employee satisfaction, the effect is not overwhelmingly large. This means that while green buildings and non-green buildings do differ in how they affect employee satisfaction, this difference is not extreme. The partial eta squared values indicate that other factors not included in this analysis might also play substantial roles in influencing employee satisfaction. Therefore, while the findings are important and suggest a meaningful impact of green buildings, there is still considerable room for other variables to influence overall employee satisfaction levels.

In all these factors, there is no significant difference between 3 types of buildings and all 3 are categorized in one subset.

Table 4.4 : Dry Air.

Duncan		
Group	N	Subset
Energy Institute	51	1.98
NEF Building	53	2.25
İTU LEE Building	33	2.33
Sig.		0.067

When examining the variable 'dryair', depicted in Table 4.4, we see that the mean satisfaction scores for the Energy Institute, NEF Building, and İTU LEE Building are 1.98, 2.25, and 2.33, respectively. The significance value (Sig.) is 0.067, which is slightly above the traditional threshold of 0.05. This implies that there are no statistically significant differences between the three buildings concerning how employees perceive the dryness of the air. Since all buildings are categorized into one subset by the Duncan test, we can conclude that employees in these buildings experience similar levels of satisfaction (or dissatisfaction) regarding air dryness.

The lack of significant differences suggests that the type of building, whether green or non-green, does not substantially affect how dry the employees find the air in their work environments. This could indicate that factors other than the building type, such as the specific HVAC systems used or localized climate control measures, might play a more crucial role in determining air dryness.

Table 4.5 : Bad Smell.

Duncan		
Group	N	Subset
Energy Institute	51	2.29
NEF Building	33	2.33
İTU LEE Building	53	2.58
Sig.		0.184

For the variable 'badsmell' , depicted in Table 4.5, the mean satisfaction scores are 2.29 for the Energy Institute, 2.33 for İTU LEE Building, and 2.58 for NEF Building. The significance value here is 0.184, indicating no statistically significant differences

between the three types of buildings regarding the presence of bad smells. This again places all buildings into one subset according to the Duncan test.

The results suggest that employees' perceptions of bad smells do not significantly differ across the three buildings, implying that factors contributing to unpleasant odors are either universally managed or universally problematic across these environments. This uniformity could stem from similar cleaning protocols, waste management practices, or air circulation systems across the buildings, irrespective of their green or non-green status.

Table 4.6 : Cold Breez.

Duncan		
Group	N	Subset
Energy Institute	33	1.91
NEF Building	53	1.98
İTU LEE Building	51	2.02
Sig.		0.563

The 'coldbreez', depicted in Table 4.6, variable shows mean scores of 1.91 for İTU LEE Building, 1.98 for NEF Building, and 2.02 for the Energy Institute, with a significance value of 0.563. This indicates no statistically significant differences among the buildings concerning the perception of cold breezes.

These findings suggest that employees in all three buildings experience cold breezes similarly. The consistent mean scores across different buildings hint at a uniform approach to managing indoor climate conditions or possibly shared structural characteristics that influence airflow. It may also indicate that employee discomfort due to cold breezes is a widespread issue not significantly mitigated by the specific type of building.

Table 4.7 : Too Cold.

Duncan		
Group	N	Subset
Energy Institute	51	1.94
NEF Building	53	2.02
İTU LEE Building	33	2.09
Sig.		0.477

For 'toocold', depicted in Table 4.7, the mean scores are 1.94 for the Energy Institute, 2.02 for NEF Building, and 2.09 for İTU LEE Building. With a significance value of 0.477, we see no significant differences between the buildings regarding the perception of the indoor environment being too cold.

This result implies that regardless of the building type, employees perceive their work environments similarly in terms of temperature being too cold. The grouping into one subset supports the notion that the measures taken to control indoor temperatures are equally effective or ineffective across the buildings, suggesting uniformity in HVAC management practices or structural insulation.

Table 4.8 : Too Warm.

Duncan		
Group	N	Subset
Energy Institute	33	2.06
NEF Building	51	2.39
İTU LEE Building	53	2.43
Sig.		0.054

The 'toowarm' variable, depicted in Table 4.8, has mean scores of 2.06 for İTU LEE Building, 2.39 for the Energy Institute, and 2.43 for NEF Building, with a significance value of 0.054. This value is just above the 0.05 threshold, indicating that the differences are not quite statistically significant, though they are close.

This near-significant result suggests that there might be a slight difference in how employees perceive warmth across the buildings, with İTU LEE Building being perceived as less warm compared to the other two. However, since the p-value is slightly above 0.05, we cannot conclusively state that the differences are statistically significant. This finding could prompt further investigation into whether green building practices in İTU LEE Building contribute to better thermal comfort.

Table 4.9 : Temperature.

Duncan		
Group	N	Subset
Energy Institute	51	2.06
NEF Building	33	2.12
İTU LEE Building	53	2.30
Sig.		0.162

For the 'temperature' variable, depicted in Table 4.9, the mean scores are 2.06 for the Energy Institute, 2.12 for İTU LEE Building, and 2.30 for NEF Building, with a significance value of 0.162. This indicates no significant differences in how employees perceive the overall temperature in their buildings.

This uniformity across building types suggests that temperature control measures are similarly effective or perceived similarly by employees in all three buildings. It could reflect consistent HVAC practices or similar building insulation standards, regardless of whether the building is green or non-green.

Table 4.10 : Warm Surface.

Duncan		
Group	N	Subset
Energy Institute	51	1.53
NEF Building	53	1.62
İTU LEE Building	33	1.70
Sig.		0.384

The 'warmsurface' variable, depicted in Table 4.10, shows mean scores of 1.53 for the Energy Institute, 1.62 for NEF Building, and 1.70 for İTU LEE Building, with a significance value of 0.384. This indicates no significant differences between the buildings in terms of employees' perceptions of warm surfaces.

The lack of significant differences implies that warm surfaces are equally present or absent across the buildings, suggesting similar construction materials or heating system designs. This consistency might point to uniform building standards or regulations that dictate the materials and methods used in all three building types.

Table 4.11 : Insufficient Light.

Duncan		
Group	N	Subset
Energy Institute	33	1.52
NEF Building	53	1.62
İTU LEE Building	51	1.69
Sig.		0.397

For 'insufficient light', depicted in Table 4.11, the mean scores are 1.52 for İTU LEE Building, 1.62 for NEF Building, and 1.69 for the Energy Institute, with a significance value of 0.397. This shows no significant differences between the buildings in terms of how employees perceive the adequacy of lighting.

The uniform perception of lighting adequacy suggests that lighting systems and natural light availability are managed similarly across all three buildings. This could reflect adherence to similar lighting standards or regulations, ensuring that all workplaces provide a comparable level of lighting, regardless of the building's green status.

Table 4.12 : Reflection.

Duncan		
Group	N	Subset
Energy Institute	51	1.94
NEF Building	33	2.03
İTU LEE Building	53	2.15
Sig.		.339

The 'reflection' variable, depicted in Table 4.12, has mean scores of 1.94 for the Energy Institute, 2.03 for İTU LEE Building, and 2.15 for NEF Building, with a significance value of 0.339. This indicates no significant differences between the buildings regarding the issue of reflections in the work environment.

This result suggests that reflections, which can be a distraction or cause discomfort, are similarly managed across the buildings. The similar mean scores indicate that factors contributing to reflections, such as window treatments, desk placements, and use of anti-glare screens, are equally effective or problematic in all three buildings.

Table 4.13 : View.

Duncan		
Group	N	Subset
Energy Institute	51	1.33
NEF Building	33	1.36
İTU LEE Building	53	1.60
Sig.		0.095

For the 'view' variable, depicted in Table 4.13, the mean scores are 1.33 for the Energy Institute, 1.36 for İTU LEE Building, and 1.60 for NEF Building, with a significance value of 0.095. This suggests no significant differences between the buildings regarding employees' satisfaction with their view.

Although the p-value is close to 0.05, it is not significant, indicating that employees' views from their workplaces are perceived similarly across the buildings. This might reflect similar architectural designs, window placements, or surrounding environments that provide comparable views for employees, irrespective of the building type.

Table 4.14 : Noise.

Duncan		
Group	N	Subset
Energy Institute	51	2.24
NEF Building	53	2.62
İTU LEE Building	33	2.64
Sig.		0.084

The 'noise' variable, depicted in Table 4.14, has mean scores of 2.24 for the Energy Institute, 2.62 for NEF Building, and 2.64 for İTU LEE Building, with a significance value of 0.084. This indicates no significant differences in noise levels perceived by employees in the three buildings.

The higher mean scores for NEF Building and İTU LEE Building suggest a trend towards higher noise levels, but the difference is not statistically significant. This could indicate that noise control measures are generally effective across all buildings, but there might be slight variations that are not large enough to be statistically confirmed. Further investigation into specific sources of noise and mitigation strategies might be warranted to understand these trends better.

Table 4.15 : Electricity.

Duncan			
Group	N	Subset	
		1	2
Energy Institute	33	1.58	
NEF Building	51	1.90	1.90
İTU LEE Building	53		2.19
Sig.		0.099	0.147

For the 'electricity' variable, depicted in Table 4.15, which measures employees' experiences with static electricity when touching surfaces, the mean scores are 1.58 for İTU LEE Building, 1.90 for the Energy Institute, and 2.19 for NEF Building. The significance values are 0.099 and 0.147, indicating that while there are differences in how employees perceive static electricity across the buildings, these differences are not statistically significant at the 0.05 level.

The Duncan test groups the Energy Institute with NEF Building, suggesting that employees in these two buildings have similar experiences with static electricity. This might indicate that the materials used in these buildings (such as carpeting, furniture, and other surface materials) have similar properties that contribute to the buildup of static electricity. On the other hand, the İTU LEE Building, with a lower mean score, suggests that employees there experience less static electricity. This could be due to different material choices or humidity control measures that reduce static buildup.

Understanding and mitigating static electricity is important for employee comfort and can also have implications for sensitive electronic equipment. The differences highlighted, even though not statistically significant, suggest that building materials and environmental controls in İTU LEE Building might be more effective in preventing static electricity. These insights could guide future decisions in material selection and building maintenance practices to improve employee comfort across all buildings.

Table 4.16 : Strong Light.

Duncan			
Group	N	Subset	
		1	2
Energy Institute	51	1.82	
NEF Building	33	1.91	1.91
İTU LEE Building	53		2.25
Sig.		0.665	0.091

The 'stronglight' variable, depicted in Table 4.16, has mean scores of 1.82 for the Energy Institute, 1.91 for İTU LEE Building, and 2.25 for NEF Building, with significance values of 0.665 and 0.091. These values indicate a marginally significant difference in how employees perceive strong light across the buildings.

The similarity between the Energy Institute and İTU LEE Building suggests that these buildings have comparable lighting conditions that result in similar employee experiences regarding strong light. The higher score for NEF Building indicates that employees there might experience stronger or more intrusive lighting conditions. This difference, though not statistically significant, could be due to variations in lighting design, the use of natural light, or the type of artificial lighting employed in the buildings.

Table 4.17 : Feeling Closed.

Duncan			
Group	N	Subset	
		1	2
Energy Institute	33	1.55	
NEF Building	51	1.59	
İTU LEE Building	53		2.36
Sig.		0.826	1.000

For the 'feelingclosed' variable, depicted in Table 4.17, the mean scores are 1.55 for İTU LEE Building, 1.59 for the Energy Institute, and 2.36 for NEF Building, with significance values of 0.826 and 1.000. This indicates a significant difference between NEF Building and the other two buildings regarding employees' feelings of being closed or confined.

The distinct difference in the NEF Building suggests that employees there feel significantly more confined compared to those in the Energy Institute and İTU LEE

Building. This could be due to various factors such as office layout, window size and placement, or overall building design. The similarity between the Energy Institute and İTU LEE Building implies that these buildings provide more open or spacious environments that mitigate feelings of confinement. Addressing these design elements in NEF Building could improve employee satisfaction regarding their spatial experience.

5. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, while green buildings represent a significant step forward in the pursuit of sustainability, this study underscores the critical importance of integrating social factors, particularly Indoor Environmental Quality (IEQ), into their design and implementation. The findings from this research highlight that policymakers, construction companies, and other relevant sectors must prioritize employee health in their sustainability efforts to create truly effective green buildings.

Enhancing employee health and productivity through improved IEQ does not only benefit individual well-being but also enhances the overall performance of businesses. Workplaces with high employee satisfaction tend to experience higher productivity, lower absenteeism rates, and better work quality. These benefits, in turn, bolster the competitive strength of businesses, making the investment in high-quality IEQ a strategic advantage.

Looking ahead, expanding research in this area and collecting more comprehensive data will provide deeper insights into the relationship between IEQ and employee satisfaction and productivity. Studies conducted across various sectors and building types will help to further elucidate the effects of IEQ on employee well-being and work performance. Such research is crucial for the continuous development and refinement of green building standards, ensuring they effectively address all aspects of sustainability.

Additionally, the findings of this study should be integrated into policy-making processes at both national and international levels. To achieve sustainable development goals, it is imperative that policymakers and industry leaders adopt and promote IEQ standards that support both environmental sustainability and employee health and productivity. This integrated approach will help ensure that green buildings contribute to a comprehensive vision of sustainable development, balancing environmental, economic, and social dimensions.

5.1 Practical Recommendations

This research offers several important practical recommendations for policymakers and the construction sector:

1. Prioritizing IEQ in Design and Construction: Green building designs should prioritize IEQ by carefully evaluating and improving key elements such as indoor air quality, lighting, acoustics, and thermal comfort. Employee satisfaction with these factors directly impacts overall job productivity and health. By considering IEQ factors more thoroughly in building design, it is possible to create healthier and more productive working environments.
2. Focusing on Employee Needs in Technology Integration: Building management systems and smart technologies should be designed with a focus on the needs and satisfaction levels of employees. For example, smart lighting and climate control systems should be adjustable to meet the individual needs of employees. Such technological solutions can enhance employee comfort while also achieving energy efficiency.
3. Regular Evaluation and Improvement Based on Feedback: Green buildings should undergo regular evaluations and improvements based on user feedback. Continuously obtaining feedback from employees about IEQ and incorporating this feedback into building management and design processes will help to optimize green buildings. This approach enables the achievement of both environmental sustainability goals and increased employee satisfaction.
4. Implementing Training and Awareness Programs: Training and awareness-raising programs should encourage employees to be informed about green building practices and the importance of IEQ. Educating employees about sustainable practices in their work environments and the effects of IEQ on their health and productivity will ensure better understanding and support of these factors.

5.2 Conclusion

Ultimately, it is clear that sustainability efforts must encompass not only environmental and economic dimensions but also social dimensions. Employee health and satisfaction are fundamental components of sustainable development, necessitating more research and practical application in this area. The importance of social sustainability should not be overlooked in the design and construction of green buildings. Solutions that maximize employee well-being alongside environmental benefits must be developed. This holistic approach will enhance the effectiveness of

green buildings and contribute significantly to the overall goal of sustainable development, which includes a balance of environmental, economic, and social dimensions. By integrating these recommendations, stakeholders can ensure that green buildings are truly sustainable, benefiting both the planet and the people who inhabit them.

One notable aspect of this research is the emphasis placed on indoor environmental quality (IEQ) as a critical determinant of occupant satisfaction and performance. The prioritization of IEQ by professionals underscores its pivotal role in shaping the overall occupant experience within green buildings. This finding resonates with previous studies highlighting the significance of factors such as thermal comfort, air quality, and lighting in influencing occupant well-being and productivity (Sadeghi et al., 2022; Mehrdad Sadeghi, 2022).

The integration of AHP facilitated a systematic evaluation of criteria and alternatives, providing quantitative insights into the relative importance of different factors in green building design. The consistency of judgments obtained from experts, as indicated by the calculated Consistency Ratio (CR), underscores the robustness of the decision-making process enabled by AHP. This methodological approach not only enhances the validity and reliability of the study findings but also contributes to advancing the field of sustainable building design research.

Furthermore, the comprehensive framework encompassing 10 key dimensions crucial for green building construction, as identified in this study, underscores the multifaceted nature of sustainability considerations in the built environment. By considering factors such as energy efficiency, water conservation, material selection, and occupant well-being, the study offers a holistic perspective on sustainable building practices. The incorporation of diverse viewpoints from experts representing various fields enriches the understanding of the complexities involved in green building design and highlights the importance of interdisciplinary collaboration in addressing sustainability challenges.

Overall, this study contributes to bridging the gap in the literature by providing insights into the variables influencing worker productivity in green buildings in the Turkish setting. By emphasizing the importance of IEQ and employing a rigorous methodological approach, the study offers valuable implications for researchers,

practitioners, and policymakers seeking to advance sustainable building practices and enhance occupant well-being in the built environment.

REFERENCES

Abbaszadeh, S., Zagreus, L., Lehrer, D., & Huizenga, C. (2006). Occupant Satisfaction with Indoor Environmental Quality in Green Buildings. *Proceedings of Healthy Buildings 2006, Lisbon, III*, 365–370. http://cbe.berkeley.edu

Abraham, Y. S., Stanitz, P., & Amaral, R. E. C. (2021). Tracking Occupant Satisfaction for Improved Energy Efficiency in Campus Buildings. *Indoor Environmental Quality Performance Approaches*. www.ashrae.org

Agha-Hossein, M. M., El-Jouzi, S., Elmualim, A. A., Ellis, J., & Williams, M. (2013). Post-occupancy studies of an office environment: Energy performance and occupants' satisfaction. *Building and Environment*, *69*, 121–130. https://doi.org/10.1016/j.buildenv.2013.08.003

Al Horr, Y., Arif, M., Kaushik, A., Mazroei, A., Katafygiotou, M., & Elsarrag, E. (2016). Occupant productivity and office indoor environment quality: A review of the literature. In *Building and Environment* (Vol. 105, pp. 369–389). Elsevier Ltd. https://doi.org/10.1016/j.buildenv.2016.06.001

Allen, J. G., MacNaughton, P., Laurent, J. G. C., Flanigan, S. S., Eitland, E. S., & Spengler, J. D. (2015). Green Buildings and Health. In *Current environmental health reports* (Vol. 2, Issue 3, pp. 250–258). Springer. https://doi.org/10.1007/s40572-015-0063-y

Altomonte, S., Schiavon, S., Kent, M. G., & Brager, G. (2019a). Indoor environmental quality and occupant satisfaction in green-certified buildings. *Building Research and Information*, *47*(3), 255–274. https://doi.org/10.1080/09613218.2018.1383715

Altomonte, S., Schiavon, S., Kent, M. G., & Brager, G. (2019b). Indoor environmental quality and occupant satisfaction in green-certified buildings. *Building Research and Information*, *47*(3), 255–274. https://doi.org/10.1080/09613218.2018.1383715

Antonelli, M. (2008). The Green Library Movement: An Overview and Beyond. *Electronic Green Journal*, *1*(27). https://doi.org/10.5070/g312710757

Arukala, S. R., Pancharathi, R. K., & Pulukuri, A. R. (2019). Evaluation of Sustainable Performance Indicators for the Built Environment Using AHP Approach. *Journal of The Institution of Engineers (India): Series A*, *100*(4), 619–631. https://doi.org/10.1007/s40030-019-00405-8

Azar, E., Nikolopoulou, C., & Papadopoulos, S. (2016). Integrating and optimizing metrics of sustainable building performance using human-focused agent-based modeling. *Applied Energy*, *183*, 926–937. https://doi.org/10.1016/j.apenergy.2016.09.022

Baird, G. (2011). Did that building feel good for you? or - isn't it just as important to assess and benchmark users' perceptions of buildings as it is to audit their energy efficiency? *Intelligent Buildings International*, *3*(2), 124–130. https://doi.org/10.1080/17508975.2011.582319

Baird, G., Leaman, A., & Thompson, J. (2012). A comparison of the performance of sustainable buildings with conventional buildings from the point of view of the users. In *Architectural Science Review* (Vol. 55, Issue 2, pp. 135–144). https://doi.org/10.1080/00038628.2012.670699

Bano, F., & Sehgal, V. (2023). Healthy Workplaces: The Impact of Building Design on Health, Productivity, and Social Well-being of an Occupant. *World Journal of Innovative Research*. https://doi.org/10.31871/WJIR.14.3.7

Brown, Z., & Cole, R. J. (2009). Influence of occupants' knowledge on comfort expectations and behaviour. *Building Research and Information*, *37*(3), 227–245. https://doi.org/10.1080/09613210902794135

Brown, Z., Cole, R. J., Robinson, J., & Dowlatabadi, H. (2010). Evaluating user experience in green buildings in relation to workplace culture and context. *Facilities*, *28*(3–4), 225–238. https://doi.org/10.1108/02632771011023168

Byrd, H., & Rasheed, E. O. (2016). The productivity paradox in green buildings. *Sustainability (Switzerland)*, *8*(4). https://doi.org/10.3390/su8040347

Cajias, M., Geiger, P., & Bienert, S. (2012). Green agenda and green performance: Empirical evidence for real estate companies. *Journal of European Real Estate Research*, *5*(2), 135–155. https://doi.org/10.1108/17539261211250717

Chatterjee, S., & Ürge-Vorsatz, D. (2021). Measuring the productivity impacts of energy-efficiency: The case of high-efficiency buildings. *Journal of Cleaner Production*, *318*. https://doi.org/10.1016/j.jclepro.2021.128535

Chiang, C.-M., & Lai, C.-M. (2002). A study on the comprehensive indicator of indoor environment assessment for occupants' health in Taiwan. In *Building and Environment* (Vol. 37). www.elsevier.com/locate/buildenv

Clements-Croome, D. J., Li, B., Clements-Croome, D., & Baizhan, L. (2000). Productivity and indoor environment Ventilation View project E-waste treatment and disposal View project PRODUCTIVITY AND INDOOR ENVIRONMENT. In *Proceedings of Healthy Buildings* (Vol. 1). https://www.researchgate.net/publication/279126933

Day, J. K., & Gunderson, D. E. (2015). Understanding high performance buildings: The link between occupant knowledge of passive design systems, corresponding behaviors, occupant comfort and environmental satisfaction. *Building and Environment*, *84*, 114–124. https://doi.org/10.1016/j.buildenv.2014.11.003

Ding, Z., Wang, Y., & Zou, P. X. W. (2016). An agent based environmental impact assessment of building demolition waste management: Conventional versus green management. *Journal of Cleaner Production*, *133*, 1136–1153. https://doi.org/10.1016/j.jclepro.2016.06.054

Dwaikat, L. N., & Ali, K. N. (2016). Green buildings cost premium: A review of empirical evidence. In *Energy and Buildings* (Vol. 110, pp. 396–403). Elsevier Ltd. https://doi.org/10.1016/j.enbuild.2015.11.021

Eichholtz, P., Kok, N., & Quigley, J. M. (2010). Doing well by doing good? Green office buildings. *American Economic Review*, *100*(5), 2492–2509. https://doi.org/10.1257/aer.100.5.2492

Eichholtz, P., Kok, N., & Quigley, J. M. (2013). THE ECONOMICS OF GREEN BUILDING. *The Review of Economics and Statistics*. http://www.energystar.gov/ia/business/evaluate_performance/office

Esfandiari, M., Zaid, S. M., Ismail, M. A., & Aflaki, A. (2017). Influence of indoor environmental quality on work productivity in green office buildings: A review. *Chemical Engineering Transactions*, *56*, 385–390. https://doi.org/10.3303/CET1756065

Feige, A., Wallbaum, H., Janser, M., & Windlinger, L. (2013a). Impact of sustainable office buildings on occupant's comfort and productivity. *Journal of Corporate Real Estate*, *15*(1), 7–34. https://doi.org/10.1108/JCRE-01-2013-0004

Feige, A., Wallbaum, H., Janser, M., & Windlinger, L. (2013b). Impact of sustainable office buildings on occupant's comfort and productivity. *Journal of Corporate Real Estate*, *15*(1), 7–34. https://doi.org/10.1108/JCRE-01-2013-0004

Fisk, W. J. (2000). Health and productivity gains from better indoor environments and their relationship with building energy efficiency. *Annual Review of Energy and the Environment*, *25*, 537–566. https://doi.org/10.1146/annurev.energy.25.1.537

Francis, A. babatunde, Chucks, O. K., & Uchenna, E. Charity. (2023). Adopting Green Building Concept to Mitigate the Effects of Climate Change on Residential Buildings in Ondo State, Nigeria. *International Journal of Multidisciplinary Research and Analysis*, *06*(06). https://doi.org/10.47191/ijmra/v6-i6-07

Fuerst, F., Mcallister, P., Van Wetering, J., & Wyatt, P. (2011). Measuring the financial performance of green buildings in the UK commercial property market: Addressing the data issues. *Journal of Financial Management of Property and Construction*, *16*(2), 163–185. https://doi.org/10.1108/13664381111153132

Gou, Z., Prasad, D., & Lau, S. S. Y. (2014). Impacts of green certifications, ventilation and office types on occupant satisfaction with indoor environmental quality. *Architectural Science Review*, *57*(3), 196–206. https://doi.org/10.1080/00038628.2014.908113

Goussous, J., & Al-Refaie, A. (2014). Evaluation of a Green Building Design Using LCC and AHP Techniques. In *Life Science Journal* (Vol. 11, Issue 8s). http://www.lifesciencesite.comhttp://www.lifesciencesite.comhttp://www.lifesciencesite.com.5

Gowri, K. (2004). Green Building Rating Systems: An Overview. *ASHRAE Journal, 46(11):56-60, 46*.

Haghighat, F., & Donnini, G. (1998). Impact of psycho-social factors on perception of the indoor air environment studies in 12 office buildings. *Building and Environment*.

Hameed, A., & Amjad, S. (2009). Impact of Office Design on Employees' Productivity: A Case study of Banking Organizations of Abbottabad, Pakistan. *Journal of Public Affairs, Administration and Management*, *3*(1).

Hedge, A., Miller, L., & Dorsey, J. A. (2014). Occupant comfort and health in green and conventional university buildings. *Work*, *49*(3), 363–372. https://doi.org/10.3233/WOR-141870

Heerwagen, J. H., & Heerwagen, J. (2000). Green Buildings, Organizational Success, and Occupant Productivity. In *Building Research and Information* (Vol. 28, Issue 5).

Heerwagen, J., Heerwagen, J., & Leah Zagreus, A. (2005). The Human Factors Of Sustaınable Buıldıng Desıgn: Post Occupancy Evaluatıon Of The Phılıp Merrıll Envıronmental Center, Annapolıs, MD. *U.S. Department Of Energy Buıldıng Technology Program*.

Hoffman, A. J., & Henn, R. (2008). Overcoming the social and psychological barriers to green building. *Organization and Environment*, *21*(4), 390–419. https://doi.org/10.1177/1086026608326129

Hong, T., Yan, D., D'oca, S., & Chen, C.-F. (2017). Ten Questions Concerning Occupant Behavior in Buildings: The Big Picture. *Energy Technologies Area*.

Hwang, B.-G., Zhu, L., & Ming, J. T. T. (2017). Factors Affecting Productivity in Green Building Construction Projects: The Case of Singapore. *Journal of Management in Engineering*, *33*(3). https://doi.org/10.1061/(asce)me.1943-5479.0000499

Hwang, R. L., Chen, W. A., & Weng, Y. T. (2022). Strengthening Taiwan's Green Building Certification System from Aspects of Productivity and Energy Costs to Provide a Healthier Workplace. *Atmosphere*, *13*(1). https://doi.org/10.3390/atmos13010118

Ildiri, N., Bazille, H., Lou, Y., Hinkelman, K., Gray, W. A., & Zuo, W. (2022). Impact of WELL certification on occupant satisfaction and perceived health, well-being, and productivity: A multi-office pre- versus post-occupancy evaluation. *Building and Environment*, *224*. https://doi.org/10.1016/j.buildenv.2022.109539

Jensen, J. O., Søgaard Jørgensen, M., Elle, M., & Lauridsen, E. H. (2012). Has social sustainability left the building? The recent conceptualization of "sustainability" in Danish buildings. *Sustainability: Science, Practice, & Policy*, *8*(1). http://sspp.proquest.com

Kamaruzzaman, S. N., Egbu, C. O., Zawawi, E. M. A., Ali, A. S., & Che-Ani, A. I. (2011). The effect of indoor environmental quality on occupants' perception of performance: A case study of refurbished historic buildings in Malaysia. *Energy and Buildings*, *43*(2–3), 407–413. https://doi.org/10.1016/j.enbuild.2010.10.003

Kaushik, A. K., Arif, M., Syal, M. M. G., Rana, M. Q., Oladinrin, O. T., Sharif, A. A., & Alshdiefat, A. S. (2022). Effect of Indoor Environment on Occupant Air Comfort and Productivity in Office Buildings: A Response Surface Analysis Approach. *Sustainability (Switzerland)*, *14*(23). https://doi.org/10.3390/su142315719

Khamkanya, T., Heaney, G., & Mcgreal, S. (2012). Introduction of AHP Satisfaction Index for workplace environments. *Journal of Corporate Real Estate*, *14*(2), 80–93. https://doi.org/10.1108/14630011211261687

Khoshbakht, M., Gou, Z., Dupre, K., & Best, R. (2018). Occupant Satisfaction and Comfort in Green Buildings: A Longitudinal Occupant Survey in a Green Building in the Subtropical Climate in Australia. *Engaging Architectural Science: Meeting the Challenges of Higher Density: 52nd International Conference of the Architectural Science Association* .

Kibert, C. J. (2016). *Sustainable Construction: Green Building Design and Delivery*. John Wiley & Sons.

Kim, S. K., Hwang, Y., Lee, Y. S., & Corser, W. (2015). Occupant comfort and satisfaction in green healthcare environments: A survey study focusing on healthcare staff. *Journal of Sustainable Development*, *8*(1), 156–173. https://doi.org/10.5539/jsd.v8n1p156

Kim, W. (2023). Post occupancy evaluation for green school building. *International Journal of Sustainable Building Technology and Urban Development*, *14*(1), 35–45. https://doi.org/10.22712/susb.20230004

Kim, Y. K., Abdou, Y., Abdou, A., & Altan, H. (2022). Indoor Environmental Quality Assessment and Occupant Satisfaction: A Post-Occupancy Evaluation of a UAE University Office Building. *Buildings*, *12*(7). https://doi.org/10.3390/buildings12070986

Kozusznik, M. W., Maricutoiu, L. P., Peiró, J. M., Vîrgă, D. M., Soriano, A., & Mateo-Cecilia, C. (2019). Decoupling office energy efficiency from employees' well-being and performance: A systematic review. In *Frontiers in Psychology* (Vol. 10, Issue FEB). Frontiers Media S.A. https://doi.org/10.3389/fpsyg.2019.00293

Lee, Y. S., & Guerin, D. A. (2010). Indoor environmental quality differences between office types in LEED-certified buildings in the US. *Building and Environment*, *45*(5), 1104–1112. https://doi.org/10.1016/j.buildenv.2009.10.019

Mallawaarachchi, H., De Silva, L., & Rameezdeen, R. (2017). Modelling the relationship between green built environment and occupants' productivity. *Facilities*, *35*(3–4), 170–187. https://doi.org/10.1108/F-07-2015-0052

Mansor, R., & Sheau-Ting, L. (2022). A measurement model of occupant well-being for Malaysian office building. *Building and Environment*, *207*. https://doi.org/10.1016/j.buildenv.2021.108561

Marzban, S., Candido, C., Avazpour, B., Mackey, M., Zhang, F., Engelen, L., & Tjondronegoro, D. (2023). The potential of high-performance workplaces for boosting worker productivity, health, and creativity: A comparison between WELL and non-WELL certified environments. *Building and Environment*, *243*. https://doi.org/10.1016/j.buildenv.2023.110708

Menadue, V., Soebarto, V., & Williamson, T. (2014). Perceived and actual thermal conditions: case studies of green-rated and conventional office buildings in the City of Adelaide. *Architectural Science Review Volume 57*.

Middlehurst, G., Yao, R., Jiang, L., Deng, J., Clements-Croome, D., & Adams, G. (2018). A preliminary study on post-occupancy evaluation of four office buildings in the UK based on the Analytic Hierarchy Process. *Intelligent Buildings International*, *10*(4), 234–246. https://doi.org/10.1080/17508975.2018.1495607

Miller, N. G., & Davis, S. M. (2009). Green Buildings and Productivity see www.josre.org. In *Forthcoming in the Journal of Sustainable Real Estate* (Vol. 1, Issue 1). www.josre.org

Miller, N. G., Pogue, D., Gough, Q. D., & Davis, S. M. (2009). Green Buildings and Productivity. *JOSRE*, *1*(1). www.josre.org.

Monfared, I. G., & Sharples, S. (2011). Occupants perceptions and expectations of a green office building: A longitudinal case study. In *Architectural Science Review* (Vol. 54, Issue 4, pp. 344–355). https://doi.org/10.1080/00038628.2011.613636

Needy, K. L., Mehmet Gokhan, N., Rettura, B., Ries, R., & Bilec, M. (2005). A Research Protocol for Analyzing Green Building Construction. *Industrial Engineering Research Conference Proceedings*.

Newsham, G. R., Birt, B. J., Arsenault, C., Thompson, A. J. L., Veitch, J. A., Mancini, S., Galasiu, A. D., Gover, B. N., MacDonald, I. A., & Burns, G. J. (2013). Do green buildings have better indoor environments? New evidence. *Building Research and Information*, *41*(4), 415–434. https://doi.org/10.1080/09613218.2013.789951

Newsham, G. R., Veitch, J. A., Zhang, M. Q., & Galasiu, A. D. (2022). Comparing better building design and operation to other corporate strategies for improving organizational productivity: a review and synthesis. *Intelligent Buildings International*, *14*(1), 3–22. https://doi.org/10.1080/17508975.2019.1588700

Nilashi, M., Zakaria, R., Ibrahim, O., Majid, M. Z. A., Mohamad Zin, R., Chugtai, M. W., Zainal Abidin, N. I., Sahamir, S. R., & Aminu Yakubu, D. (2015). A knowledge-based expert system for assessing the performance level of green buildings. *Knowledge-Based Systems*, *86*, 194–209. https://doi.org/10.1016/j.knosys.2015.06.009

Nurick, S., & Thatcher, A. (2023). Examining the impact of indoor environmental quality on individual productivity of knowledge workers in green certified buildings. *Journal of Corporate Real Estate*, *25*(4), 307–324. https://doi.org/10.1108/JCRE-11-2022-0036

Ohueri, C. C., Bamgbade, J. A., Chuin, A. L. S., Hing, M. W. N., & Enegbuma, W. I. (2022). Best Practices in Building Information Modelling Process Implementation in Green Building Design: Architects' Insights. *Journal of*

Construction in Developing Countries, *27*(1), 79–93. https://doi.org/10.21315/jcdc2022.27.1.5

Ooshaksaraie, L. (2022). Application of analytic hierarchy process in the green building criteria comparison. In *Proceedings of the International Academy of Ecology and Environmental Sciences* (Vol. 2022, Issue 3). www.iaees.org

Rashid, M., Spreckelmeyer, K., & Arch, D. (2012). GREEN BUILDINGS, ENVIRONMENTAL AWARENESS, AND ORGANIZATIONAL IMAGE. *Journal of Corporate Real Estate*. www.usgbc.org

Rastogi, A., & Kumar Paul, V. (2022). Impact of Green Building on Productivity of Offices. *Sixth Building Simulation and Optimisation Virtual Conference*. https://www.researchgate.net/publication/369186202

Roetzel, A., & Chen, C.-F. (2016). Understanding architectural and social-psychological influences on occupant behaviour in commercial buildings. *50th International Conference of the Architectural Science Association 2016*, 567–576.

Roumi, S., Zhang, F., Stewart, R. A., & Santamouris, M. (2023). Weighting of indoor environment quality parameters for occupant satisfaction and energy efficiency. *Building and Environment*, *228*. https://doi.org/10.1016/j.buildenv.2022.109898

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences*, *1*(1), 83–98. https://doi.org/10.1504/IJSSCI.2008.017590

Sadeghi, M., Naghedi, R., Behzadian, K., Shamshirgaran, A., Tabrizi, M. R., & Maknoon, R. (2022a). Customisation of green buildings assessment tools based on climatic zoning and experts judgement using K-means clustering and fuzzy AHP. *Building and Environment*, *223*. https://doi.org/10.1016/j.buildenv.2022.109473

Sadeghi, M., Naghedi, R., Behzadian, K., Shamshirgaran, A., Tabrizi, M. R., & Maknoon, R. (2022b). Customisation of green buildings assessment tools based on climatic zoning and experts judgement using K-means clustering and fuzzy AHP. *Building and Environment*, *223*. https://doi.org/10.1016/j.buildenv.2022.109473

Samaranayake, S. U., De Silva, S., Samaranayake, S. U., & Silva, D. (2010). Effect Of Green Workplace Envıronment On Employee Performance Emerging Adults' Multiple Role Balance Management Expectations View Project Municipal Waste Management View Project Effect Of Green Workplace Envıronment On Employee Performance. *International Conference on Sustainable Built Environment (ICSBE-2010)*, 13–14. https://www.researchgate.net/publication/304560626

Sanmargaraja, S., Olanrewaju, A., Tarique, M., & Lim, C. H. (2023, June 20). A Review of How Occupant Behaviour Determines the Energy Efficiency of Green Buildings: A Case of Office Buildings. *13th International Conference on Industrial Engineering and Operations Management (IEOM)*. https://doi.org/10.46254/an13.20230358

Senouci, R., Taibi, N. E., Teodoro, A. C., Duarte, L., Mansour, H., & Meddah, R. Y. (2021). Gis-based expert knowledge for landslide susceptibility mapping (LSM): Case of Mostaganem coast district, west of Algeria. *Sustainability (Switzerland)*, *13*(2), 1–21. https://doi.org/10.3390/su13020630

Sentman, S. D. (2000). Healthy Buildings: Green Building Standards, Benefits, and Incentives. *Annual Review of Energy and the Environment*, *25*, 537–566. https://doi.org/10.1146/annurev.energy.25.1.537

Shi, Q., Zuo, J., Huang, R., Huang, J., & Pullen, S. (2013). Identifying the critical factors for green construction - An empirical study in China. *Habitat International*, *40*, 1–8. https://doi.org/10.1016/j.habitatint.2013.01.003

Singh, A., Syal, M., Grady, S. C., & Korkmaz, S. (2010). Effects of green buildings on employee health and productivity. *American Journal of Public Health*, *100*(9), 1665–1668. https://doi.org/10.2105/AJPH.2009.180687

Soldatou, N., Chatzianastasiadou, P., & Vagiona, D. G. (2022). Assessment of Carbon-Related Scenarios for Tourism Development in the Island of Lefkada in Greece. *Tourism and Hospitality*, *3*(2), 345–361. https://doi.org/10.3390/tourhosp3020023

Steemers, K., & Manchanda, S. (2010). Energy efficient design and occupant well-being: Case studies in the UK and India. *Building and Environment*, *45*(2), 270–278. https://doi.org/10.1016/j.buildenv.2009.08.025

Steinemann, A., Wargocki, P., & Rismanchi, B. (2017). Ten questions concerning green buildings and indoor air quality. *Building and Environment*, *112*, 351–358. https://doi.org/10.1016/j.buildenv.2016.11.010

Sutadian, A. D., Muttil, N., Yilmaz, A. G., & Perera, B. J. C. (2017). Using the Analytic Hierarchy Process to identify parameter weights for developing a water quality index. *Ecological Indicators*, *75*, 220–233. https://doi.org/10.1016/j.ecolind.2016.12.043

Voordt, T. van der, & Jensen, P. A. (2023). The impact of healthy workplaces on employee satisfaction, productivity and costs. In *Journal of Corporate Real Estate* (Vol. 25, Issue 1, pp. 29–49). Emerald Publishing. https://doi.org/10.1108/JCRE-03-2021-0012

Walker, M. B., Salaga, S., & Mercado, H. (2016). Determinants of managerial engagement in environmental responsibility in the public assembly facility sector. *Management Decision*, *54*(8), 2084–2102. https://doi.org/10.1108/MD-04-2016-0242

Wener, R., & Carmalt, H. (2006). Environmental psychology and sustainability in high-rise structures. *Technology in Society*, *28*(1–2), 157–167. https://doi.org/10.1016/j.techsoc.2005.10.016

Wyon, D. P. (1996). *Indoor Envıronmental Effects On Productıvıty*.

Xiong, Y., Krogmann, U., Mainelis, G., Rodenburg, L. A., & Andrews, C. J. (2015). Indoor air quality in green buildings: A case-study in a residential high-rise building in the northeastern United States. *Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering*, *50*(3), 225–242. https://doi.org/10.1080/10934529.2015.981101

Zhao, D., McCoy, A. P., Agee, P., Mo, Y., Reichard, G., & Paige, F. (2018). Time effects of green buildings on energy use for low-income households: A longitudinal study in the United States. *Sustainable Cities and Society*, *40*, 559–568. https://doi.org/10.1016/j.scs.2018.05.011

Zuo, J., & Zhao, Z. Y. (2014). Green building research-current status and future agenda: A review. In *Renewable and Sustainable Energy Reviews* (Vol. 30, pp. 271–281). https://doi.org/10.1016/j.rser.2013.10.021

APPENDICES

APPENDIX A: Questionnaire For Experts

APPENDIX B: Questionnaire For Occupants

APPENDIX A: Questionnaire For Experts

What is your gender?

Female ☐ Male ☐

What is your age?

Under 30 years old ☐ 30-40 years old ☐ 40-50 years old ☐

50-60 years old ☐ Over 60 years old ☐

What is your educational level?

Bachelor ☐ Master ☐ PHD ☐ Post DOC ☐

Do you have application experience in sustainability?

Yes ☐ No ☐

At what point are you in sustainability studies?

Manager ☐ Consulting Firm ☐ Academic ☐ Decider ☐ Finance ☐

How much is your experience in sustainability studies?

0-5 years ☐ 5-10 years ☐ 10-15 years ☐ 15-20 years ☐ Over 20 years☐

In which field are you working?

……

……..

Which of the following factors has a more significant positive impact on workforce productivity in green offices?

* If criterion A is very important compared to B, values close to 9 on the left should be given, and if it is the opposite, values closer to 9 on the right should be given. If they are of equal importance, please mark 1.

	Criteria A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Criteria B
	less relative importance of **A** compared to **B**																		
1	Energy Efficiency and Conservation																		Water Conservation and Management
2	Energy Efficiency and Conservation																		Material Selection and Sourcing
3	Energy Efficiency and Conservation																		Indoor Environmental Quality
4	Energy Efficiency and Conservation																		Site Selection and Land Use
5	Energy Efficiency and Conservation																		Waste Management and Recycling
6	Energy Efficiency and Conservation																		Adaptability and Resilience
7	Energy Efficiency and Conservation																		Innovation and Technology Integration

	Criteria A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Criteria B
8	Energy Efficiency and Conservation																		Occupant Well-being and Satisfaction
9	Energy Efficiency and Conservation																		Life Cycle Assessment and Long-term Impact
10	Water Conservation and Management																		Material Selection and Sourcing
11	Water Conservation and Management																		Indoor Environmental Quality
12	Water Conservation and Management																		Site Selection and Land Use
13	Water Conservation and Management																		Waste Management and Recycling
14	Water Conservation and Management																		Adaptability and Resilience
15	Water Conservation and Management																		Innovation and Technology Integration
16	Water Conservation and Management																		Occupant Well-being and Satisfaction

	Criteria A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Criteria B
17	Water Conservation and Management																		Life Cycle Assessment and Long-term Impact
18	Material Selection and Sourcing																		Indoor Environmental Quality
19	Material Selection and Sourcing																		Site Selection and Land Use
20	Material Selection and Sourcing																		Waste Management and Recycling
21	Material Selection and Sourcing																		Adaptability and Resilience
22	Material Selection and Sourcing																		Innovation and Technology Integration
23	Material Selection and Sourcing																		Occupant Well-being and Satisfaction
24	Material Selection and Sourcing																		Life Cycle Assessment and Long-term Impact
25	Indoor Environmental Quality																		Site Selection and Land Use

	Criteria A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Criteria B
26	Indoor Environmental Quality																		Waste Management and Recycling
27	Indoor Environmental Quality																		Adaptability and Resilience
28	Indoor Environmental Quality																		Innovation and Technology Integration
29	Indoor Environmental Quality																		Occupant Well-being and Satisfaction
30	Indoor Environmental Quality																		Life Cycle Assessment and Long-term Impact
31	Site Selection and Land Use																		Waste Management and Recycling
32	Site Selection and Land Use																		Adaptability and Resilience
33	Site Selection and Land Use																		Innovation and Technology Integration
34	Site Selection and Land Use																		Occupant Well-being and Satisfaction

	Criteria A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Criteria B
35	Site Selection and Land Use																		Life Cycle Assessment and Long-term Impact
36	Waste Management and Recycling																		Adaptability and Resilience
37	Waste Management and Recycling																		Innovation and Technology Integration
38	Waste Management and Recycling																		Occupant Well-being and Satisfaction
39	Waste Management and Recycling																		Life Cycle Assessment and Long-term Impact
40	Adaptability and Resilience																		Innovation and Technology Integration
41	Adaptability and Resilience																		Occupant Well-being and Satisfaction
42	Adaptability and Resilience																		Life Cycle Assessment and Long-term Impact

	Criteria A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Criteria B
43	Innovation and Technology Integration																		Occupant Well-being and Satisfaction
44	Innovation and Technology Integration																		Life Cycle Assessment and Long-term Impact
45	Occupant Well-being and Satisfaction																		Life Cycle Assessment and Long-term Impact

APPENDIX B: Questionnaire For Occupants

General information

1.Gender ☐ Male ☐ Female

2.Age range

20-30 ☐ 30-40 ☐ 40-50 ☐ 50-60 ☐ more than 60 ☐

3. Educational Level

No education ☐ Elementary school ☐ Secondary school ☐ High school ☐ Academic degree ☐ Doctor of philosophy ☐ Other ☐

4. Employment status

Managing people or resources ☐ research work ☐ using specialist skill ☐ doing clerical, secretarial or administrative work ☐ other ☐

5. How long have you been working in this room? ……. year …….month

6. How many days per week do you normally work at your desk? ……. days

7. How many hours per day do you normally work at your desk? ……. hours

8. How many hours per day do you normally operate a PC at work? ……. hours

How often do you feel annoyed (uncomfortable) by the followings?

	often	regularly	sometimes	never
9.dry air	□	□	□	□
10.stuffy/bad smell	□	□	□	□
From/where:	1.outside / 2.inside / 3.stairways and landings / 4. Toilets / 5.heating system / 6. Ventilation system / 7. other			
11.static electricity	□	□	□	□
12.draught unpleasant cold breeze	□	□	□	□

From/where: 1.windows / 2.stairways and landings / 3.office door / 4.external wall / 5.ventilation system / 6.heating system / 7.ceilling / 8.other

13.too cold	□	□	□	□
When:	1.winter 2.spring 3.summer 4.autumn			
14.too warm	□	□	□	□
When:	1.winter 2.spring 3.summer 4.autumn			
15.tempurature changing during the day	□	□	□	□
16.cold feet	□	□	□	□
17.warm surface	□	□	□	□
Where:	1.ceilling / 2.outer wall / 3.windows / 4. Floor(warm feet) / 5.other			
18.too much or too strong light	□	□	□	□
Why:	1.too much artificial light / 2.too much day light / 3.other			
19.insufficient light	□	□	□	□
Why:	1.too little artificial light / 2.bad quality of lighting system / 3.too little day light / 4.other			
20.reflections or glare	□	□	□	□
Caused by:	1.windows / 2.lighting system / 3.other			
21.unacceptable view	□	□	□	□

22.feeling closed in	□	□	□	□
23.noise	□	□	□	□

From: 1.from outside / 2.adjacent rooms / 3.offices below / 4.offices above / 5.toilets / 6.stair ways and corridors / 7.heeting system / 8.ventilation system / 9. Lifts / 10.escalators / 11.mail elevators /12.automatic distribution system / 13.cleaning system / 14.colleagues in the office / 15.equipment in the office / 16.machinery in building / 17.other

How much control do you feel you have over the following?

	Not enough	little	reasonable	enough
24.temperature	□	□	□	□
25.ventilation	□	□	□	□
26.light	□	□	□	□

If you are at the office for more than 4 hours, do you have experience any of the following symptoms?

	often	regularly	sometimes	never
27.dry/watering eyes	□	□	□	□
28.blocked/runny nose	□	□	□	□
29.dry/irritated throat	□	□	□	□
30.chest tightness	□	□	□	□
31.dry/irritated skin	□	□	□	□
32.headaches	□	□	□	□
33.lethargy/tiredness	□	□	□	□

34.pain in neck, shoulders or back □ □ □ □

About your room

35.How many other people normally are in the r0om where you work …… people

36.which of the following equipment/items are present in your office room?

PC / (laser)printer / humidifier / ionizer / plants / other

About yourself

37.have you ever suffered from fever or other allergic reactions? □yes □no

38.have you ever had asthmatic problems? □yes □no

39.have you ever suffered from eczema? □yes □no

40.do you mind us visiting your office? □yes □no

41.if you have any comments or remarks you can put them here.

……

……

……

……

……

Thank you for your time

CURRICULUM VITAE

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