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Abstract

This research aims to establish an innovative framework for assessing the sustainability of public buildings and schools in Palestine. Palestine was chosen because of its complex political circumstances, diverse environmental challenges, and complex social and economic conditions.

The research addresses various dimensions, including environmental, economic, and social aspects, intending to promote sustainable practices in the educational system, particularly in schools. To achieve these goals, the thesis starts with a comprehensive literature review of previous research (Chapter 1) to identify research gaps and select adequate sustainability assessment tools emphasizing Palestine. A comprehensive review of the relationship between sustainability and education is then conducted (Chapter 2) to discuss the importance of the concept of 'education for sustainability". Based on the literature review, a research methodology is established (Chapter 3) emphasizing the sustainability framework, tools, strategies, and methods for data analysis. A comprehensive sustainability assessment framework is established for the Palestinian school system (Chapter 4). It includes 35 indicators within 11 sustainability categories. The framework assesses the sustainability of a large set of schools in Palestine (Chapter 5).

This assessment revealed low levels of sustainability in Palestinian schools. It also shows a pressing need to support schools' environmental, economic, and social sustainability. The research concludes with recommendations, including energy-efficient building codes, green building principles, renewable energy, rainwater harvesting, waste segregation, promoting social inclusion, enhancing student engagement, and increasing interior quality.

Keywords : Sustainability, Assessment, Public Buildings, School, Education, Framework, social, environmental

Résumé

Cette recherche vise à établir un cadre innovant pour évaluer la durabilité des bâtiments publics et des écoles en Palestine. La Palestine a été choisie en raison de sa situation politique complexe, de ses divers défis environnementaux et de ses conditions sociales et économiques. La recherche aborde diverses dimensions, notamment les aspects environnementaux, économiques et sociaux, dans le but de promouvoir des pratiques durables dans le système éducatif, en particulier dans les écoles.

Pour atteindre ces objectifs, la thèse commence par une revue complète de la littérature sur les recherches antérieures (chapitre 1) pour identifier les lacunes de la recherche et sélectionner des outils d'évaluation de la durabilité en mettant l'accent sur la Palestine. Un examen complet de la relation entre la durabilité et l'éducation est ensuite réalisé (chapitre 2) pour discuter de l'importance du concept d'« Éducation pour la Durabilité ». Sur la base de l'analyse de la littérature, une méthodologie de recherche est établie (chapitre 3) mettant l'accent sur le cadre de durabilité, les outils, les stratégies et les méthodes d'analyse des données. Un cadre complet d'évaluation de la durabilité est ensuite établi pour le système scolaire palestinien (chapitre 4). Il comprend 35 indicateurs répartis en 11 catégories de durabilité. Ce cadre est utilisé pour évaluer la durabilité d'un groupe d'écoles en Palestine (Chapitre 5). Cette évaluation révèle un faible niveau de durabilité dans ces écoles. Cette évaluation montre également un besoin urgent de soutenir la durabilité des écoles dans les dimensions environnementale, économique et sociale.

La recherche se termine par un ensemble de recommandations, notamment pour des codes de construction économes en énergie, des principes de construction écologique, l'adoption d'énergies renouvelables, la récupération des eaux de pluie, le tri des déchets, la promotion de l'inclusion sociale, l'amélioration de l'engagement des étudiants et l'amélioration de la qualité intérieure.

Mots-clés : Durabilité, Évaluation, Bâtiments publics, École, Éducation, Cadre, social, environnemental

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General Introduction

Research Background

As stated in the United Nations 2030 Sustainable Development Goals, sustainability means balancing our current needs with those of future generations without compromising on either (Bungau et al., 2022). The United Nations' 17 Sustainable Development Goals encompass many goals, from ending poverty and hunger to promoting clean energy, gender equality, and climate action (Segovia-Hernández et al., 2023). This is to ensure the well-being and prosperity of current and future generations. Sustainability is the harmonious coexistence of three main aspects: environmental, social, and economic. The environmental aspect emphasizes the conservation of natural resources, the reduction of carbon emissions, and the preservation of ecosystems and biodiversity (Meena et al., 2022). It takes action to combat climate change, protect forests and oceans, and ensure clean air and water for all. The social aspect focuses on improving human well-being and quality of life (Gurmu et al., 2022). This includes eradicating poverty and hunger, promoting health and well-being, ensuring quality education, and promoting gender equality and social inclusion. The economic aspect seeks prosperity through sustainable economic growth, industry, and innovation (Wartoyo & Haida, 2023). This includes creating inclusive economies that create jobs, foster innovation, and support responsible consumption and production patterns. The United Nations Sustainable Development Goals provide for a comprehensive and coherent approach that recognizes the interdependence of these aspects. Sustainable development is not just a goal, but a shared responsibility and requires concerted efforts to secure a better future for people and the planet.

Public buildings, including educational institutions, occupy a key position as community centers and have the potential to support sustainable practices (Gao et al., 2023). Incorporating sustainability into these structures mitigates environmental impacts and promotes understanding of the importance of sustainability in the community. As educational bastions, schools play a central role in promoting sustainability, as early childhood is a crucial time to shape attitudes and highlight the need for sustainability education (Gueler Yıldız et al., 2021). Sustainable schools reduce their environmental impact while promoting a healthy indoor environment. They educate students who value and promote environmental stewardship (Marouli, 2021). In addition, integrating sustainability into public spaces such as schools promotes diversity, safety, well-being, and community engagement. These places can inspire people to adopt sustainable lifestyles and engage in group activities to address critical social issues (ALTAN, 2020). In addition, implementing sustainable practices in schools reduces operating costs, uses resources efficiently, manages waste appropriately, and improves financial sustainability (Maneejuk & Yamaka, 2021). Students who are familiar with sustainable practices are also better prepared to work in fields that promote environmental protection and green technologies that contribute to economic growth.

Given the importance of building sustainability, some countries have developed sustainability assessment tools. These tools play a pivotal role in identifying, assessing, and managing progress toward sustainability in buildings (Marchi et al., 2021). These structured methods

enable informed decision making, facilitate goal setting, and highlight areas for improvement. In addition, assessment tools enable stakeholders to fully understand the interplay between environmental, social, and economic dimensions, ensuring a holistic approach to achieving sustainability goals (Vitale et al., 2021). Examples of such tools include BREEAM, LEED, SBTool, CASBEE, NABERS, and HQE, which provide an assessment of building sustainability (Assefa et al., 2022). It is becoming increasingly clear that specific tools are needed for certain buildings, such as offices, residences, hospitals, malls, and shopping centers, such as BREEAM Education (2008), LEED for Schools (2013), and SBTool for K-12 schools (T. Saraiva et al., 2020).

Despite the availability of school sustainability assessment tools, a scientific gap needs to be addressed to make further progress in this area. Existing tools often focus primarily on environmental aspects such as energy and water efficiency and pay less attention to the social and economic dimensions of sustainability. Although the K-12 SBTool balances the three dimensions of sustainability, no specific indicator of environmental education is part of education for sustainability.

The main objective of this research is to develop a comprehensive sustainable building assessment framework and tool for public buildings in Palestine, especially schools. This methodology aims to create a consistent and reliable evaluation system that will allow schools to be evaluated based on identified performance indicators and benefits for sustainability. The expected outcome is the adoption of this evaluation approach that will lead to the protection of the environment, the promotion of social well-being, and local economic development within the Palestinian community.

Given the political realities and lack of resources, Palestine provides a unique case study for sustainable building practices. Occupation impacts the construction sector and sustainable development, while resource constraints highlight the need for innovative solutions (Abu Hamed & Peric, 2020). Given the unique environmental conditions in the West Bank and the high population density, it is important to achieve a balance between growth and sustainability. Transforming Palestinian education into sustainable education empowers students to cope with life's complexities, contribute to research, and solve real-world challenges while protecting the environment and supporting socioeconomic development.

Significance of the Study

The importance of this study is that it contributes to sustainable development by addressing the main challenges in assessing public buildings, especially schools, in the Palestinian context. This study establishes guidelines for incorporating sustainability criteria into government policies and regulations by developing an assessment framework that ensures a consistent approach. It also improves the environmental, social and economic aspects of public buildings and schools by identifying areas that need significant improvement in line with the overall sustainable development goals. The study also builds mechanisms for monitoring and evaluating sustainability performance that enable adaptive management and schools to assess and track sustainability progress. In addition, the study supports effective communication of sustainability initiatives with stakeholders and promotes transparency and

participation while encouraging students to engage in sustainable practices and promote sustainability awareness and advocacy. Finally, the study disseminates best practices and innovative methodologies for assessing the sustainability of public buildings, which contribute significantly to regional sustainable development efforts.

Thesis Outline

The thesis is presented in five chapters:

Chapter 1. This chapter provides a comprehensive and critical review of the literature on the three aspects of sustainability: the concept of sustainability in the construction sector and public buildings, the characteristics of sustainability assessment tools and their comparison. In addition, the research gap is discussed.

Chapter 2. This chapter provides a comprehensive overview of the relationship between sustainability and education and the importance of the concept of 'education for sustainability'. It also discusses the concept of sustainable schools, the importance of a holistic approach to sustainability in schools, and the role of stakeholders.

Chapter 3. This chapter explains the research methodology, including data analysis tools, strategies, and methods.

Chapter 4. This chapter presents the structure and development of the sustainability assessment framework for the Palestinian school system. It describes the categories and indicators selected for the evaluation of the schools, as well as the role of the experts in determining the weights and importance of these indicators.

Chapter 5. This chapter discusses the results of the assessment of sustainability in Palestinian schools and provides recommendations for improving school sustainability.

Chapter 1 Sustainability in Public Buildings - Literature Review

1.1 Introduction

Buildings and the construction sector are essential components of the fabric of cities. They provide housing, mobility, water, and health infrastructures and form the physical framework for social interactions and economic development at the micro level. Numerous studies have also shown a link between buildings and public health. Therefore, the building and construction sector is one of the most important sectors that offers opportunities to reduce environmental impacts and contribute to the achievement of the Sustainable Development Goals. At the same time, the built environment is responsible for a significant portion of energy and greenhouse gas emissions associated with energy and waste generation and natural resource use.

Sustainable building is a broader concept that encompasses various aspects of sustainability, including the three pillars: environmental, social, and economic considerations. It aims to create buildings with minimal negative impact on the environment while promoting social equity and economic viability (Balabel & Alwetaishi, 2021). In contrast, green building focuses on environmental aspects and aims to reduce a building's carbon footprint, save resources, and improve indoor environmental quality (T. Saraiva et al., 2020). In addition, sustainable construction often adopts a life-cycle perspective that considers the entire life cycle of the building, from design and construction, through operation and maintenance, to demolition or reuse. This approach evaluates the long-term impact of the building and encourages the use of durable and recyclable materials (Y. Zhang et al., 2019).

The sustainability rating system for buildings has been around for nearly two decades. Sustainability certifications are specifically designed for buildings to recognize and promote sustainable building practices. These certifications are awarded to buildings that meet certain standards and criteria related to environmental, social, and economic sustainability. The most common and widely used sustainability certifications for buildings include BREEAM, LEED, Green Star, CASBEE, GBTool, and Estidama (Mourad & Wahid, 2022). These certification programs provide a framework for building owners, developers, and designers to implement sustainable practices and gain recognition for their efforts in creating environmentally and socially responsible buildings. The accreditation process involves rigorous evaluation, documentation, and verification of a building's sustainability performance, resulting in the award of sustainability certification at various levels, depending on the level of performance. These certifications serve as evidence of the building's commitment to sustainability and help raise awareness of the importance of green and sustainable building practices in the construction industry.

This chapter addresses various aspects of sustainability in the construction and building sector, with the first section highlighting environmental, social, and economic benefits. The second section focuses on sustainability in public buildings, recognizing their importance to economic growth, quality of life improvements, and environmental impacts. While public

buildings play an important role in promoting sustainability, they also face several challenges, including insufficient research in this area. The third section focuses on the most prominent global assessment frameworks used to evaluate the sustainability of buildings. A comparative analysis of these frameworks and their main contributions to the assessment process is provided, as well as insight into researchers' efforts to develop new frameworks. Finally, this chapter highlights the scientific gaps that underlie this research and identifies areas for further research and improvement. By addressing these gaps, the chapter aims to help advance sustainable practices in the construction industry, particularly in public buildings.

1.2 Sustainability in the Construction and Building Sector

The construction industry drives economic growth, promotes social progress, and provides effective environmental protection. However, despite the many benefits that buildings provide to individuals and society, they also have a major impact on human health and the environment. This impact is evident at various stages during the life of a building, including design, construction, operation, and maintenance (Invidiata et al., 2018). A major concern is the large amount of energy and natural resources that buildings consume during their lifetime. Buildings account for 32% of the total energy consumption in the world (Zou et al., 2019). The construction industry consumes many natural resources, 25% wood and steel products and 70% cement (Jensen et al., 2018). This heavy reliance on energy and resources places a huge burden on the environment and exacerbates climate change and resource depletion.

In developed countries, the construction sector is responsible for extracting 40% of natural resources, consuming 70% of electrical energy, and using 12% of drinking water. It also generates a large amount of waste in landfills, accounting for between 45% and 65% of the total waste generated (Omer & Noguchi, 2020). In addition, buildings contribute significantly to greenhouse gas emissions, which increases their impact on the environment. Approximately 30% of these emissions occur during the operational phase of buildings, while another 18% result from material consumption and transportation (Kumar Sharma, 2020). These emissions do not contribute to global warming and threaten air quality and human health.

Given these statistics, it is imperative that we address the negative impacts of buildings on our environment. We must find and implement effective ways to reduce the environmental footprint of buildings. By adopting sustainable design practices, promoting energy efficiency, utilizing renewable energy sources, and implementing innovative building technologies, we can significantly reduce the harmful impact of buildings on our planet. Therefore, sustainable architecture has become essential in today's world (Damirchi Loo & Mahdavinejad, 2018). It is about creating man-made environments that coexist harmoniously with the surrounding ecosystem and living organisms throughout the life cycle of a building. Interestingly, (Mushtaha et al., 2019) highlighted that these buildings have a natural harmony with their surroundings, climate, design, and people. This shows that the concept of sustainable architecture is not entirely new. However, the availability of modern technologies and advanced tools in our time has accelerated the extensive and rapid development of this idea.

Sustainable building practices are gaining more and more importance due to their positive impact on the environment, economy, and society around the world. By integrating environmentally friendly design, resource efficiency, and social responsibility, sustainable construction offers a number of benefits that contribute to a more sustainable and resilient future, as illustrated in the following subsections.

1.2.1 Environmental Benefits of Sustainable Buildings

Sustainable building emphasizes energy-efficient design and the use of renewable energy sources. By using energy-efficient technologies and materials, buildings can significantly reduce carbon emissions, a major contributor to global warming. Sustainable buildings can save up to 40% more energy than conventional buildings, which increases energy efficiency and reduces carbon emissions (Nguyen & Gray, 2016). In addition, low-carbon materials in these buildings have been shown to reduce building life-cycle emissions by up to 30% (Qiao & Liu, 2020).

(Nguyen & Gray, 2016) also stated that one of the main goals of sustainable construction is to reduce environmental impacts and construction waste. Dealing with construction and demolition waste is important for the development of sustainable building design. This is because a large amount of construction waste can lead to air and water pollution (Nižetić et al., 2019). The value of construction waste recycling rate should be more than 90%, which can reduce the impact of waste generation (Asman et al., 2019). Consequently, construction materials play an important role in sustainable development and can help create a healthier and safer environment. (Y. Li et al., 2019) emphasize that wood is an environmentally sustainable building material that reduces energy consumption and carbon dioxide emissions.

Sustainable building principles and strategic siting help protect ecosystems. According to (T. Liu et al., 2022), choosing building sites away from environmentally sensitive areas and implementing measures to minimize soil erosion during construction helps protect nearby ecosystems and water bodies. In addition, green infrastructure elements such as green roofs and walls help restore biodiversity in urban environments and provide habitats for plants and animals. These elements also help mitigate the urban heat island effect and improve air quality.

1.2.2 Social Benefits of Sustainable Buildings

Sustainable buildings provide important social benefits that are enhanced by corporate social responsibility efforts. Companies are increasingly prioritizing environmental issues and taking voluntary action to reduce greenhouse gas emissions, which contributes to corporate social responsibility goals. By renovating sustainable buildings, companies can improve their corporate image, leading to corporate reputation and potential financial benefits (Li Zhang et al., 2018). This makes it easier for companies to attract investors and ultimately lower their cost of capital. In addition, investors who support sustainable standards may receive incentives, such as preferential land prices from local governments (Balaban & Puppim de Oliveira, 2017). An increasing focus on green buildings creates competitive markets that drive the development of greener and more sustainable buildings.

Buildings have a direct impact on human health as people spend a lot of time indoors. Therefore, indoor environmental quality (IEQ) is becoming a critical factor in the benefits of green buildings. Compared to traditional buildings, green buildings can achieve higher levels of IEQ, resulting in better occupant health and greater occupant satisfaction (Maryam Khoshbakht et al., 2018). Light distribution, an important aspect of indoor lighting, can influence mental health and work efficiency (Balaban & Puppim de Oliveira, 2017). In addition, indoor air quality plays an important role in both building performance and occupant health (Karji et al., 2021). It should be noted that occupants of certified green buildings had 6% better sleep quality than non-certified buildings (Elshafei et al., 2017). A focus on IEQ in green buildings significantly improves overall well-being and promotes a healthy work and living environment.

Other notable social benefits of a sustainable building include increased occupant productivity and well-being, and reduced absenteeism. (Gawande et al., 2020) found that the prevalence of sick building syndrome (SBS) in green buildings is 38.1%, lower than 53.1% in traditional buildings. The benefits of these buildings are interrelated and can have significant impacts for both occupants and businesses. For example, in sustainable commercial buildings, improved productivity and occupant well-being leads to reduced absenteeism, which ultimately leads to financial gains for businesses (M. Khoshbakht et al., 2017). This highlights the synergy between the different benefits of these buildings and shows how positive outcomes in one aspect (in this example, the social aspect) can lead to positive outcomes in another aspect (the economic aspect).

1.2.3 Economic Benefits of Sustainable Buildings

An important economic benefit of sustainable buildings is the potential for cost savings through energy and water efficiency, which help reduce total cost of ownership (Hafez et al., 2023). Because these buildings use less energy and water, they result in lower utility bills, long-term cost savings for building owners and occupants, and environmental benefits. (Alsulaili et al., 2020) conducted a case study on the conversion of a traditional building into a green building in Kuwait and its impact on energy and water expenditures. The holistic approach resulted in a significant reduction in water and energy consumption, which brought significant financial benefits and environmental improvements. He explained that by implementing energy-saving measures such as LED, sensors and timers, the building achieved an impressive 86% reduction in energy waste from lighting, resulting in an annual cost savings of 54%. This not only resulted in significant financial gains, but also contributed to a significant reduction in carbon dioxide and greenhouse gas emissions of approximately 65,893 kilograms annually. In addition, the use of high-quality insulation, low-profile, double-glazed windows, and ventilation ducts has resulted in a significant 25% reduction in HVAC cooling load, which in turn contributes to a reduction in greenhouse gas emissions of approximately 90,262 kilograms annually. In addition, the installation of photovoltaic panels has resulted in an annual electricity production of 6,770 kWh, which increases the sustainability of the building. The use of environmentally friendly paint instead of regular paint resulted in an impressive 88% reduction in volatile organic compounds (VOCs), improving indoor air quality and the overall well-being of the building's occupants.

Sustainable buildings are gaining recognition and value in the real estate market. Investors and tenants are increasingly attracted to green-certified buildings because they offer long-term economic benefits, such as lower operating costs and environmentally friendly features, which increase property values. In addition to increasing asset value, these buildings also have higher rental values compared to conventional properties, some of which are summarized in Table 1.1. These values vary depending on the market and the level of environmental certification of the buildings.

Table 1.1. Summary of increase in asset values and green building rents (2010-2020). (Source: (Kieu & Schäfer, 2020))

Increase in Asset Value	Increase in Rent Value	Building Types	Country or Region	Source of Reference
43%	23%	Office	Germany	(Ott & Hahn, 2018)
7.4-11% (In avg. 9.2%)	-	Office	Italy	(Mangialardo et al., 2018)
2.6-4.1% (In avg. 3.2%)	-	Residential	Singapore	(Fesselmeyer, 2018)
2%	-	Commercial	Singapore	(Harris, 2018)
4.4%	-	Residential	Hong Kong	(Hui et al., 2017)
6.9%	-	Residential	China	(L Zhang et al., 2017)
-	3-4%	Office	U.S.	(Devine & Kok, 2015; Stanley & Wang, 2017)
-	5-8%	Office	U.S.	(Stanley & Wang, 2017)
11.8%	6.6%	Office	Australia	(Newell et al., 2014)

Sustainable building is sparked by a strong focus on improving occupant health and productivity, making it a top social priority. However, the business sector stands to benefit greatly from these efforts. (Kieu & Schäfer, 2020) showed that savings obtained through improved occupant health and increased labour productivity can vary, ranging from $2 to $680 per square meter and from $64 to $17,778 per employee. Exact numbers depend on various factors, including the business's specific requirements in terms of workspace, number of employees, and spending rates. In conclusion, sustainable building offers many economic benefits, including cost savings through energy and water efficiency, increased asset value in the real estate market, and reduced operating expenses over the life of the building. These financial advantages and the positive environmental and social impacts make these buildings an attractive and wise choice for investors and building owners.

1.3 Sustainability in Public Buildings

Public buildings can be defined as structures that are owned, operated, or financed by the government or public agencies and designed to meet the needs of the public (Gao et al., 2023). Public buildings include offices, commercial buildings, educational institutions, hospitals, museums, sports centers, and other buildings that can be used for various public activities. Each building type also has several specific building types. For example,

educational buildings include educational institutions, schools, universities, libraries, and laboratories. The public sector is an important indicator of social and economic development in every country. It provides essential services, promotes inclusion and civic identity, and serves as a space for community participation and development, which is central to the well-being and prosperity of communities. Public buildings also have a significant impact on the environment, particularly in terms of energy and water consumption. Therefore, this sector and buildings require high investments and policies to renovate this sector and meet sustainability challenges (Soliño, 2019). The next two subsections discuss the importance of public buildings in society and the challenges of transforming public buildings into sustainable buildings.

1.3.1 Role and Importance of Public Building in Society

The role and importance of public buildings in society is complex and significant. These buildings serve as important institutions and symbols of civic identity, critical to meeting community needs and fostering a sense of belonging and pride. The following are some of the key aspects that underscore the role and importance of public buildings in society:

1. Providing essential services. Public buildings house essential services and facilities that are essential to the well-being and functioning of the community. They provide citizens with access to education, health care, cultural resources, and social support, contributing to social well-being and community development (Gao et al., 2023).
2. Inclusivity and accessibility. Public buildings are designed to be inclusive and accessible to all members of society, regardless of age, ability, or background. They must ensure that every person can use the facilities comfortably and independently. This focus on inclusion promotes social justice, strengthens a sense of belonging for all people, and promotes community sustainability (Andersson, 2021).
3. Symbol of civic identity. Public buildings often serve as symbols of civic pride and identity. Their architectural design and location within the community contribute to their significance as landmarks representing government institutions or community values. They can become iconic structures that evoke a sense of belonging and connection to the local community (Jong & Lu, 2022).
4. Community gathering spaces. Public buildings such as community centers and libraries serve as gathering spaces where people can meet, socialize, and participate in various activities. These spaces encourage community participation and collaboration and create opportunities for residents to interact and share ideas (Haldane et al., 2019).
5. Promote sustainable practices. Public buildings incorporate sustainable design principles to reduce environmental impact and improve energy efficiency. Public buildings can inspire individuals and organizations to take environmentally friendly actions by serving as role models for sustainable practices, contributing to overall environmental awareness (Barton et al., 2021).
6. Incentives for economic development. Public buildings can serve as a catalyst for economic development by attracting investment and businesses to the area. Well-designed public infrastructure, such as transportation hubs and cultural centers, can

stimulate economic activity and improve the overall quality of life for residents (Liberalesso et al., 2020).

7. Preservation of cultural heritage. Some public buildings, such as museums and historic monuments, play a critical role in preserving cultural heritage and historical significance. They display art, artifacts, and historical exhibits, enrich the cultural fabric of the community, and foster collective memory (Lo Faro & Miceli, 2021).
8. Emergency and disaster response. Public buildings often function as emergency and disaster response centers, providing safe spaces and resources during a crisis. They can serve as evacuation centers, medical facilities, or relief coordination centers, helping communities cope with unexpected challenges (Fang et al., 2020).

1.3.2 Challenges of Implementing Sustainability in Public Building

Public buildings play a crucial role in sustainable development. However, implementing sustainability in these buildings presents complex and multi-faceted challenges. For example, (Rock et al., 2019) examined barriers to building sustainability in commercial office buildings in Australia by surveying facility managers. They categorized the barriers into seven groups: finance-related, property-related, tenancy-related, construction-related, perceived benefits, organizational considerations, and architectural or atmospheric influences. We note how diverse these barriers are and how they vary in economic, political, social, and other ways. Therefore, this section aims to identify and analyze the key challenges to sustainable practices in public buildings.

Economic Challenges

Sustainable buildings often face challenges due to the high initial costs associated with innovative technologies (Hajare & Elwakil, 2020). The construction costs of sustainable buildings can be about $10/m2 to $30/m2 higher than conventional buildings (S. Li et al., 2020). Higher LEED certification levels for buildings are usually associated with higher construction expenditures. For example, in Thailand, certified buildings with silver, gold, and platinum levels have 1.17%, 2.15%, and 8.92% higher construction costs than conventional buildings, respectively (Taemthong & Chaisaard, 2019). On the other hand, the energy consumption of sustainable buildings can be 34% lower than conventional constructions. In comparison, more than 75% of these buildings have additional initial construction costs between 0% and 4% (S. Li et al., 2020). This shows that stakeholders and decision makers often focus on initial expenditures when planning construction and ignore the long-term benefits of durable structures and investments.

The second major barrier to the adoption of sustainable buildings is the lack of market demand (Guribie et al., 2021). Different countries have different market demands for sustainable buildings, which creates opportunities and challenges for the development of the sustainable buildings market. Understanding market conditions and related factors, such as low capital and weak regulatory structures, is critical to the development of the sustainable buildings market (Kwofie et al., 2016). Economic recessions and financial constraints around the world have put pressure on construction projects, making investors reluctant to consider capital-intensive sustainable building projects (Dalibi et al., 2017). Addressing these issues

can improve the competitiveness of the sustainable construction market, promote sustainable economic development, and reduce environmental impact. Collaboration between potential market participants and governments is essential to ensure sustainable development in urban areas using sustainable construction information at social, cultural, and institutional levels.

Social Challenges

Lack of public awareness and participation are major barriers to the social aspect of sustainable building development (Kim et al., 2020). Many contractors, homeowners, and builders lack a clear understanding of sustainable development issues, which hinders the implementation of sustainable building goals (Agyekum et al., 2019). Despite decades of providing sustainable building theories and increasing awareness among building professionals, the information available to clients is limited and sometimes misleading. In addition, the concept of sustainability is relatively new in many developing countries, resulting in lower use of sustainable buildings and reduced social benefits (Ohiomah et al., 2019).

One of the challenges in constructing sustainable buildings is the lack of public participation. Traditional urban development planning usually follows a top-down approach, while sustainable urban planning aims for a bottom-up process. However, the actual implementation and its impacts may not be apparent to all stakeholders and participants throughout the planning process (Hongyang et al., 2018). Consumers play a critical role in the rapid and healthy development of green buildings and are key stakeholders in the buying and selling process. Therefore, it is necessary to increase public participation by understanding consumer attitudes and demand for green buildings.

Policies and Institutional Regulations

The main barriers to the development of sustainable construction in terms of policy can be divided into two areas: lack of government financial incentives and inadequate regulations and legal frameworks (Addy et al., 2021). Lack of government incentives is an institutional challenge that hinders the growth of sustainable building initiatives. To encourage people to invest in sustainable buildings, these projects need to be made more attractive, which can be achieved through incentives for green builders (Ohiomah et al., 2019). These incentives can take various forms, such as exemptions from certain utility costs or subsidies for additional building space. For example, research in Ghana has found that tax cuts for contractors involved in green building projects and lower import tariffs on green building materials would significantly encourage the adoption of green building practices (Chan et al., 2018).

One of the biggest challenges is the lack of political support for providing public funding to convert existing public buildings into sustainable buildings. The benefits of sustainable public buildings may not be immediately apparent, and politicians often prioritize short-term outcomes to prove their merit and win more votes (Atmoko et al., 2019). To address this issue, the government needs to provide a clear set of key performance indicators and demonstrate rapid successes of sustainable public buildings programs to convince politicians of the program's effectiveness. Presenting tangible and measurable results can help build political support for investing in sustainable building initiatives.

Part Two: Governments play a critical role in promoting sustainable buildings by implementing favorable regulations that encourage compliance with sustainable principles (Atmoko et al., 2019). Enforcement of these regulations is critical to the success of government strategies. However, the lack of an enforcement body can jeopardize the implementation of these strategies, especially as new regulations are developed for sustainable buildings (Agyekum et al., 2019). Another problem is that current sustainable building assessment strategies may not be appropriate for different cities with regional differences (Raouf & Al-Ghamdi, 2019). For example, in developed cities such as Beijing and Shanghai in China, the assessment criteria are very simple, so many projects can easily meet the requirements. On the other hand, regions in China with slow economic development, such as Guizhou and Gansu, face extremely high standards that few projects can meet (Matisoff et al., 2016). Therefore, stricter laws and penalties for non-compliance can effectively promote the development of green building (Ayman et al., 2020).

Technological Limitations & Capacity-Building Requirements

New technologies are important to accelerate the transformation of the construction market towards sustainability. Improving the overall technological system in green building can create an effective platform for promoting and connecting new technologies. However, the lack of certain technologies, such as building data modeling (BIM), is a major obstacle to the development of green buildings (B. Huang et al., 2021). BIM is widely used in architecture, civil engineering, and construction, and contributes to industry efficiency of the industry and evaluating the sustainability of green buildings. However, the high initial cost and poor interoperability between different programs hinder the widespread adoption of BIM models in some projects (B. Huang et al., 2021). Companies using different software face the challenge of designing the same project on different platforms, leading to problems in information transfer and communication between planning departments (Kjaer et al., 2019). Therefore, updating green building design software is crucial for promoting the development of the construction industry.

In addition, to successfully implement sustainability in construction projects, it is essential to meet capacity building requirements. To ensure the effective integration of green building practices, there is a need to invest in training and education programs for architects, contractors, and other construction professionals (Sahid et al., 2020). By providing sustainable construction knowledge and experience, the industry can overcome challenges related to skills gaps and ensure the smooth implementation of green building initiatives. Capacity-building initiatives can enable professionals to implement sustainable technologies and designs, which ultimately promotes the growth of green building projects and supports the Sustainable Development Goals.

This section highlights the economic, social, political, and technological barriers to implementing sustainability in public buildings. In particular, we focus on sustainable building assessment policies and regulations, which need to be further improved, taking into account regional differences. Strengthening these policies and tools can lead to effective monitoring and evaluation systems that are critical to the ongoing success of sustainability initiatives. In the next section, we look at global building sustainability assessment

regulations and how they can be developed to promote sustainability in different sectors. By addressing this challenge and promoting adaptable global regulations, we aim to advance the cause of sustainability in buildings.

1.4 Sustainability Assessment Tools

Sustainability assessment tools are collections of best practices and indicators used to evaluate the sustainability performance of buildings, infrastructure, policies, and other projects (Zarghami & Fatourehchi, 2020). Indeed, sustainability rating tools are commonly referred to as Green Building Rating Systems worldwide. They aim to measure and evaluate the environmental, social and economic aspects of the project to ensure its compatibility with sustainable development goals and principles. Sustainability assessment tools are applied in various fields, including architecture, urban planning, infrastructure development, and policy formulation (Y. Zhang et al., 2019). The development of sustainable assessment tools dates back to the growing awareness of environmental issues and the need for sustainable practices in the 20th century. Early efforts focused on single aspects, such as energy efficiency or waste management. However, as the understanding of sustainability deepened, comprehensive frameworks emerged to holistically assess a project's impacts across multiple dimensions.

Sustainability assessment tools aim to protect and preserve the environment and human health and ensure economic growth (Vitale et al., 2021). By providing a standardized methodology for evaluating projects, these tools facilitate comparisons and help stakeholders make informed decisions. They encourage the adoption of environmentally friendly practices such as energy-efficient design, use of renewable resources, and waste reduction. In addition, these tools also promote social inclusion by ensuring that projects address the needs of diverse populations and vulnerable communities. As a result, they are widely used in the construction industry to design environmentally friendly buildings and neighborhoods. They also guide policymakers in developing regulations and incentives to promote sustainable practices. Governments and international organizations often rely on these tools to assess their sustainability performance and set goals for a greener future.

Despite their advantages, sustainability assessment tools are not without problems. One major problem is the different regional and cultural contexts that require these tools to be adapted to specific local conditions (Shan & Hwang, 2018). In addition, the proliferation of different classification systems can lead to confusion among stakeholders, highlighting the need for harmonization and standardization. There is no consensus-based approach to assigning weights for evaluation criteria, and the way weights are calculated and the rationale for assigned values in current systems are not clear and unambiguous (Mahmoud et al., 2018).

1.4.1 Sustainability Indicators

Common and clear sustainability indicators are needed to provide a framework for measuring the sustainability performance of buildings during their life cycle. The certificates contain different indicators that are used as metrics, each with a weighting and scoring system (Balaras et al., 2019). However, the difficulty is that these indicators are influenced by local conditions, government policies, and geographic conditions in each country in general, and

the needs and importance of buildings in particular. As a result, there is still no agreement on a type or number of sustainable indicators. Moreover, there is no consensus on the rating system of indicators that can be expressed as ratios or numerical values.

To ensure the effectiveness of these tools, indicators must have certain characteristics (Reid & Rout, 2020; Stanitsas et al., 2021): (I) Indicators must be measurable, quantifiable, and allow for objective assessment of project sustainability performance. (II) They must be relevant and aligned with the objectives of the assessment tool and reflect the key sustainability impacts of the project. In addition, indicators must be specific and clearly defined to avoid ambiguity and ensure consistent interpretation and application. (III) A holistic approach to indicators is essential, covering different dimensions of sustainability, including environmental, social and economic aspects, to enable a comprehensive assessment of a project's impacts. (IV) Stakeholder involvement is critical in the development of indicators as this ensures their relevance and acceptability, with input from experts, practitioners and affected communities. (V) Indicators must be adaptable to local conditions and cultural contexts. Evolvability is also critical. Indicators must be adaptable to changing knowledge, technologies, and best practices in sustainable development.

In Europe, several organizations from seven countries have joined forces to produce the Joint European Sustainable Built Environment Assessment for Mediterranean Cities (CESBA MED). This aims to produce a representative list of indicators at the building level, which will then be extended to the neighborhood level to cover the main pillars of sustainability. 216 indicators were identified and grouped under key sustainability themes. This information is divided into three classifications: Themes, Categories, and Criteria Indicators. These classifications are defined as follows (Balaras et al 2020):

- “Issues” define the general themes necessary to assess sustainability in building and neighbourhood (urban) standards. For the building scale, the sustainable issues are seven issues: A-Site and infrastructures, B-Energy and resources, C-Environment, D-Indoor Environmental Quality (IEQ), E-Service quality, F-Social, cultural, and perceptual aspects, and G-Economy. And there are seven sustainable Issues for the neighbourhood (urban) scale: A-Urban systems, B-Economy, C-Energy, D-Emissions, E-Natural resources, F-Environment, and G-Social aspects.
- Under each issue, the "Categories" describe their specific aspects that collect relevant criteria-indicators. In the building scale there are 25 Categories. For example, under the “B-Energy and resources” issue there are four categories: B.1-Life cycle non-renewable energy, B.2- Electricity peak demand, B.3- Materials, B.4- Potable-, rain-, grey-water. The neighbourhood scale has 23 categories. For example, under the “A-Urban system” issue there are two categories: A.1-Urban structure and form, and A.2-Tansportation Infrastructure.
- The “Criteria” defines the specific aspects of the category and represents the main valuation entries used to describe a building or urban area. There are 24 indicators for building scale only, 142 indicators for neighbourhood scale only, and 50 for both building and neighbourhood scales (Balaras et al 2020). Occasionally qualitative criteria are used in place of quantitative criteria. In this case, the expert evaluation relies on

specific reference descriptions to assess and record the specific performance. For example, at the building scale, the criteria “F.2.1 Compatibility of urban design with local cultural values” in the category “F.2 Culture and Heritage” is qualitatively evaluated by indicating whether architectural design features connected to urban design are compatible or marginally or incompatible (Balaras et al., 2019).

1.4.2 Development of Sustainability Assessment Tools

In the early 1990s, the concept of building environmental assessment methods emerged to measure the environmental performance of buildings. The Building Research Establishment (BRE) was among the pioneers in introducing the first system that set standards for best practices in the design and operation of sustainable buildings. Originally, the environmental assessment method was designed to evaluate the environmental performance of buildings. The general features of this method include (a) consideration of minimizing pressure on natural resources and preserving environmental value, (b) rating buildings with a focus on the health and well-being of their occupants, and (c) providing a scoring system through a simple additive method to indicate priority.

In addition, BRE asserts that the building rating methodology can play an important role in stimulating market demand for sustainable buildings, thereby raising awareness among key stakeholders and occupants about low environmental impact construction. Recognizing the importance of such tools, many countries have now adopted them to help building stakeholders evaluate their projects according to sustainable development principles. As a result, there are 60 rating systems that have been summarized specifically for the design and certification of sustainable buildings in different countries (Tebbouche et al., 2017). All of these approaches provide environmental certification for sustainable buildings - both existing and future buildings. These are: UK's BREEAM, US LEED, Green Star in Australia and South Africa, Japan's CASBBE, Switzerland's MENERGIE, Germany's DGNB as well as HQE in France, Estidama for the United Arab Emirates, EDAMA for Jordan, and Lebanon's ARZ Building Rating System approach (see Figure 1.1).

The three most popular sustainability assessment tools, BREEAM, LEED, and SBTool are of great interest in the field of sustainable building and construction practices. Their widespread adoption across many countries and their influence in shaping subsequent assessment tools make them essential focal points for research in this field. Table 1.2 summarizes the main features of these tools, according to (Assefa et al., 2022; BRE, 2023; IISBE, 2023; LEED, 2023; Marchi et al., 2021; Y. Zhang et al., 2019).

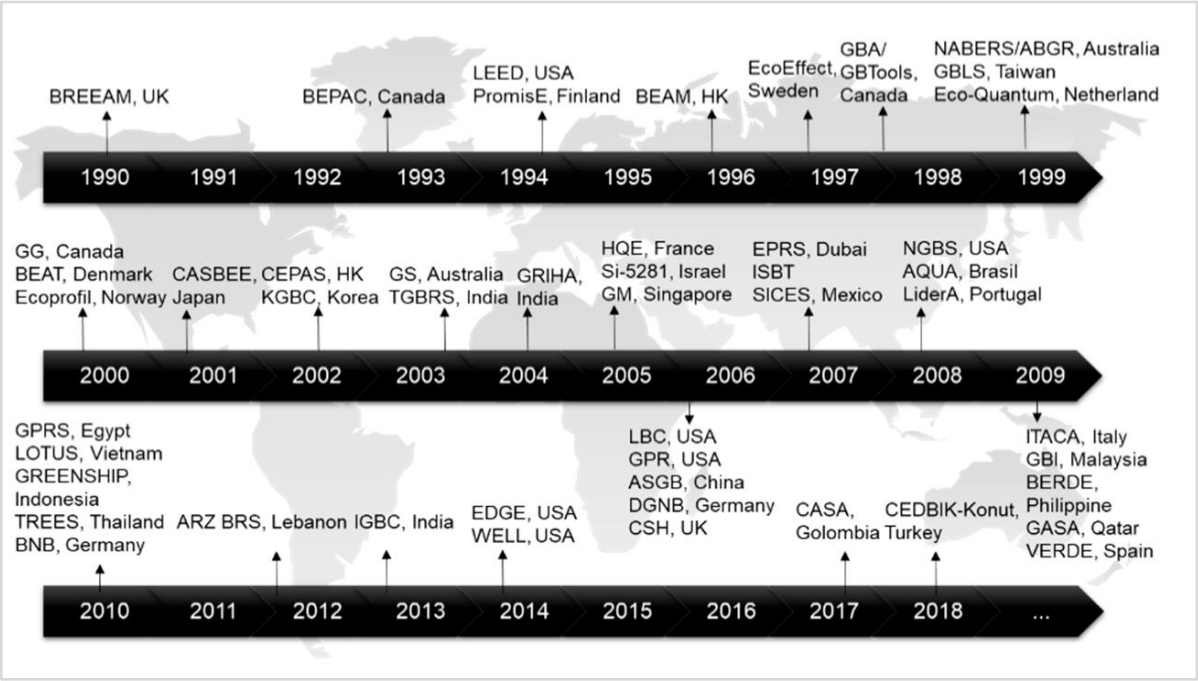

Figure 1.1. The Timeline of Sustainability Assessment tools Development (Source: (Y. Zhang et al., 2019)).

Table 1.2. The main features of the well-known sustainability assessment tools.

Tool	BREEAM	LEED	SBTool
Country	United Kingdom	United States	Canada
Developed Year	1990	1994	1998
Leading Organization	Building Research Establishment (BRE)	U.S. Green Building Council (USGBC)	International Initiative for a Sustainable Built Environment (iiSBE)
Full Name	Building Research Establishment's Environmental Assessment Method	Leadership in Energy and Environmental Design	Sustainability Building Tool
Sustainability Categories	Management, Health and Wellbeing, Energy, Transport, Materials, Water, Waste, Land Use and Ecology, Pollution, and Innovation	Sustainable Site, Indoor Environmental Quality, Water Efficiency, Energy & Atmosphere, Materials & Resources, Innovation & Regional Priorities	Site Selection, Project Planning and Development, Energy and Resources, Environmental Loadings, Indoor Environmental Quality, Service Quality, Economic and Social Aspects, Cultural and Perceptual Aspects
Type of Buildings	Residence, Retail, Industry unit, Office, Court, School, Healthcare, Prison, Multifunction Building,	Residence, School, Retail, Commercial Building, Healthcare, Multifunction Building.	Almost any Building

	Unusual Building.		
Weighting System	Additive Pre-weighted Credits Approach	Additive Simple Approach (1 for 1)	Additive Weighting after Scoring
Flexibility	Flexible in the UK, and relatively overseas	Flexible in the USA, and relatively overseas	High flexibility around the world
Ratings	• Unclassified < 30 • Pass ≥ 30 • Good ≥ 45 • Very Good ≥ 55 • Excellent ≥ 70 • Outstanding ≥ 85	• Certified 40-49 Points • Silver 50-59 Points • Gold 60-79 Points • Platinum 80+ Points	• -1 = Unsatisfactory • 0 = Min. Acceptable Performance • 1 to 4 = Intermediate Performance Levels • 2 = Normal Default • 5 = Best Practice
No. of Certified Buildings	594,011 (till 2021)	79,418 (till 2021)	--
No. of Countries Used	89	167	28

1.4.3 Major Categories for Selected Sustainability Assessment Tools

This section provides an overview of the major categories in selected sustainability assessment tools. This analysis allows us to understand which areas of sustainability are commonly addressed and which these tools may overlook. Understanding the strengths and limitations of each tool contributes to a comprehensive assessment of its effectiveness in promoting sustainable practices.

Indoor Environment Quality

Indoor environmental quality is an important objective in all environmental assessment tools, with the goal of providing occupants with a healthy and comfortable environment (Licina et al., 2021). This includes adequate lighting levels, noise control, ventilation, thermal comfort, and protection from potential hazards such as microbiological contamination or emissions of indoor pollutants. BREEAM refers to this category as “Health and Well-Being,” while LEED and SBTool call it “Indoor Environmental Quality” Each tool covers the key indoor environment standards differently, as shown in Table 1.3. LEED focuses primarily on low-emitting materials, while BREEAM and SBTool focus more on HVAC, lighting, and lighting. Interestingly, the LEED rating process seems to ignore acoustic performance. In addition, SBTool includes testing for electromagnetic pollution and acknowledges the potential hazards these fields can pose to building occupants, although there is some doubt about their health effects.

Table 1.3. The comparison of indoor environment quality category in selected assessment tools.

Indicators of Indoor Environment Quality		BREEAM	LEED	SBTool
Lighting and Illumination	Lighting controllability	❋	❋	❋
	View out	❋	❋	❋

	Glare measure & control	⁕	⁕	⁕
	Illumination level	⁕	⁕	⁕
	Daylight factor (DF)	⁕	⁕	⁕
Noise & Acoustics	Noise level	⁕	⁕	⁕
	Sound insulation	⁕		⁕
	Sound absorption	⁕	⁕	⁕
Ventilation	Potential of natural ventilation	⁕	⁕	⁕
	Ventilation system	⁕	⁕	⁕
	Air purification – supply of fresh air	⁕	⁕	⁕
	Air quality sensors- CO_2 monitoring	⁕	⁕	⁕
Thermal Comfort	Zoned control	⁕	⁕	⁕
	Cooling/heating/ humidity control & comfort	⁕	⁕	⁕
Contaminat-ion Level	Volatile organic compounds (VOC)	⁕	⁕	⁕
	Electromagnetic pollution			⁕
	Microbiological contamination level	⁕	⁕	⁕

The Covid-19 pandemic has highlighted the importance of Indoor Environmental Quality (IEQ). Lockdown measures have been imposed across the world to contain the spread of the Coronavirus. According to the China National Green Building Evaluation Standard, certified green buildings play a vital role in reducing infection risks and preventing transmission during an epidemic (T. Liu et al., 2022). Contributions of green buildings to the health of residents during COVID-19 include: (1) controlling concentrations of indoor air pollutants to promote occupant health, (2) preventing mold growth and related health issues such as asthma and allergies, (3) ensuring water safety to avoid health risks from improper pipe connections, and (4) using antibacterial green building materials to benefit residents.

Sustainable Site and Ecology

The sustainable sites category plays an important role in reducing potential pollution from on-site construction activities while providing for environmental preservation through control of soil erosion, river sedimentation, carbon dioxide emissions, and biodiversity protection, as shown in Table 1.4. This category also focuses on promoting effective connectivity and accessibility, providing easy access to public services and related facilities, and meeting the needs of bicyclists, motorists, and pedestrians. BREEAM also divides this category into Land Use & Ecology and Transportation, which is consistent with the LEED sustainable site category. BREEAM and LEED both endorse similar standards related to environmental protection and site accessibility, but LEED places a particular emphasis on redevelopment and encouraging the use of public transportation to reduce environmental impacts (LEED, 2023). BREEAM, on the other hand, focuses on preserving biodiversity and promoting sustainable transportation options (BRE, 2023). SBTool also addresses the sustainable website aspect, specifically in the website development category (IISBE, 2023). This tool understands the importance of land use planning and its impact on the built environment. It emphasizes the careful allocation of land for indoor uses to ensure optimal land use planning and minimize negative impacts on the surrounding environment.

Table 1.4. The comparison of sustainable site & ecology category in selected assessment tools.

Indicators of Sustainable Site & Ecology		BREEAM	LEED	SBTool
Construction Site	Site Selection	*	*	*
	Site protection	*	*	*
Ecological Value	Contaminated land	*	*	*
	Mitigation ecological impact	*	*	*
	Enhance site ecology	*	*	*
	Biodiversity protection	*	*	*
Transport	Accessibility	*	*	*
	Density development	*	*	*
	Community connectivity	*	*	*
	Pedestrian & Cyclist safety	*	*	*
	Car parking capacity	*	*	*

Energy Efficiency

Energy efficiency design is important in sustainability rating systems because it has a significant impact on the environment. Therefore, energy efficiency measures account for the largest share of credits in the environmental categories. These rating systems recognize the critical role of energy design, renewable energy strategies, energy conservation, and monitoring in promoting efficient use of environmental resources and addressing environmental threats such as global warming, sea level rise, and acid rain (see Table 1.5). BREEAM, LEED, and SBTool all assess carbon dioxide emissions and energy use, which requires the use of complementary tools and guidance such as Standard Assessment Procedures (SAP) and American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE). BREEAM includes additional criteria such as indoor and outdoor lighting, Global Warming Potential (GWP), and the use of eco-labeled products (BRE, 2023).

Table 1.5. The comparison of energy efficiency category in selected assessment tools.

Indicators of Energy Efficiency		BREEAM	LEED	SBTool
Energy Performance	HVAC system	*	*	*
	Ventilation rate	*	*	*
	Lighting: internal	*	*	*
	Lighting: external	*		*
	Hot water system	*	*	*
	Heat transmission	*	*	*
Natural Resources	Renewable energy technology	*	*	*
Efficient Operation	Energy monitoring	*	*	*
	Optimum performance and Energy saving	*	*	*
	CO_2 mitigations strategy	*	*	*
	Insulant GWP			*

Water Efficiency & Waste Management

Water conservation has become a major global issue as water is recognized as a limited and precious resource. In response, sustainability assessment systems focus on the efficient management of water use to reduce the consumption of primary water resources. To achieve this goal, strategies such as rainwater harvesting, graywater recycling, and irrigation system isolation are used, as shown in Table 1.6. In addition, the treatment of wastewater and solid waste is very important due to their serious impacts on human health and environmental pollution. To combat waste-related risks, waste treatment and recycling facilities are essential components of well-developed waste management systems. By incorporating these practices, people and their surrounding environment can be protected from the negative impacts of waste while reaping the benefits of remediation and recycling.

While most of the criteria and sub-criteria in this section are evaluated in all three evaluation schemes, the SBTool evaluation framework stands out when examining the criterion of groundwater recharge under environmental stress (IISBE, 2023). This assessment is important to ensure efficient water use, especially in areas where groundwater remains the primary source of water supply.

Table 1.6. The comparison of water efficiency & waste management categories in selected assessment tools.

Indicators of Water Efficiency & Waste Management		BREEAM	LEED	SBTool
Water Efficiency	Water Consumption	⁕	⁕	⁕
	Rainwater harvesting	⁕	⁕	⁕
	Grey water recycling	⁕	⁕	⁕
	Water fixture & conservation strategy	⁕	⁕	⁕
	Irrigation system	⁕	⁕	⁕
	Recharge of ground water			⁕
	Innovation wastewater technology	⁕	⁕	
Waste Management	Construction waste management	⁕	⁕	⁕
	Waste treatment	⁕	⁕	⁕
	Recycling facilities	⁕	⁕	⁕

Materials & Pollution

The main goal of sustainable principles is to ensure best practices for the consumption of resources, including energy, materials, and water. Consequently, building materials play a critical role in most assessment schemes due to their complex life cycle, from raw material extraction to disposal. Sustainability assessment tools aim to mitigate the potential impacts of material use by adhering to the following practices: (i) minimizing the use of virgin resources, (ii) minimizing energy use in extraction, processing, and transportation, (iii) adopting water-efficient practices in manufacturing, (iv) avoiding the use of contaminated and non-native materials, and (v) promoting the use of recyclable and environmentally friendly materials (see Table 1.7). BREEAM includes to some extent additional and more specific criteria within this category. On the other hand, LEED places more emphasis on the

reuse and maintenance of building materials, but the assessment framework covers surface materials and responsible sourcing of materials relatively little (LEED, 2023). In terms of considering environmental impact, SBTool emphasizes minimizing the use of non-renewable resources and avoiding materials with environmentally harmful content (IISBE, 2023).

Protecting the environment is a primary goal of sustainable construction and an important consideration when evaluating a building's surroundings. Key factors such as potential natural hazards, pollutants, hazardous emissions, and light pollution are paramount in the assessment (see Table 1.7). The three sustainability assessment tools deal with potential natural hazards and pollution differently. For example, BREEAM focuses on assessing factors that could increase the potential for global warming and associated impacts. This is done by assessing refrigerant leakage and hazardous emissions, including nitrogen oxides and carbon dioxide. On the other hand, LEED specifically assesses heat island impacts. SBTool uses several criteria to evaluate atmospheric emissions during a facility's operation, including ozone-depleting substances, acid emissions, and photo-oxidant emissions.

Table 1.7. The comparison of material & pollution categories in selected assessment tools.

Indicators of Material & Pollution		BREEAM	LEED	SBTool
Material	Material with low environmental impact	⁕	⁕	⁕
	Re-use of structural frame materials	⁕	⁕	⁕
	Use of non-renewable – virgin materials	⁕	⁕	⁕
	Use of non-structural materials	⁕	⁕	⁕
	Building fabric component (insulation)	⁕	⁕	⁕
	Use of finishing materials	⁕		⁕
	Responsible source of materials	⁕		⁕
	Material efficiency over its life cycle (LCA)	⁕	⁕	⁕
Pollution	Night light & Noise pollution	⁕	⁕	⁕
	Refrigerant GWP – building services	⁕	⁕	⁕
	Preventing refrigerant leaks	⁕		
	Watercourse pollution	⁕	⁕	⁕
	NOx emissions from heating source	⁕		⁕
	CO_2 emissions	⁕	⁕	⁕
	Fire risk	⁕	⁕	⁕
	Natural disaster	⁕	⁕	⁕
	Heat island effect		⁕	

Building Management & Innovation

The primary management focus of most assessment tools is the effective management of site activities and the construction process. The main objective is to ensure the protection of social and environmental aspects and to ensure an appropriate level of commissioning. BREEAM focuses on providing building guidelines that provide a clear understanding of how buildings can be operated and maintained efficiently in line with their sustainable

principles. In addition, increasing local ownership through consultation with relevant stakeholders during the design process is an important consideration as this brings in different perspectives to save resources and improve management strategies (BRE, 2023). Table 1.8 shows that BREEAM is distinctive in that it independently establishes the key principles of sustainable management and focuses on integrating management issues into its assessment framework. In comparison, LEED can be seen as relatively weaker in this area, with a less clear focus on the principles of sustainable management. SBTool has similar guidelines to BREEAM and addresses management issues in a separate category, with a greater focus on planning and coordinating the construction process.

In the innovation category, both BREEAM and LEED have introduced additional criteria to encourage and recognize exemplary performance in all areas of sustainability, including procurement strategy, design features, management processes, and technological developments. These additional criteria reflect exceptional performance beyond the standard requirements (LEED, 2023). Unlike BREEAM and LEED, SBTool does not provide specific criteria for recognizing exemplary performance in sustainable aspects (see Table 1.8).

Table 1.8. The comparison of material & pollution categories in selected assessment tools.

Indicators of Material & Pollution		BREEAM	LEED	SBTool
Building Management	Commissioning	❋	❋	❋
	Home user guid	❋		❋
	Construction process planning			❋
	Construction site impacts	❋		
	Consultation	❋		
	Considerate constructors	❋		❋
	Security	❋		
Innovation	Exemplary performance	❋		
	Innovation in design	❋	❋	

Socio-Economic Categories

Socioeconomic indicators are the most important aspects considered in sustainability assessment tools. These indicators assess the social and economic impacts of construction projects, ensuring that they contribute positively to the well-being of communities and promote equitable and inclusive development. In LEED and BREEAM, social indicators are addressed through various criteria within the assessment framework. The focus is on aspects such as community connectivity, access to public transportation, and proximity to amenities and services. Projects that prioritize pedestrian-friendly design, encourage the use of public transportation, and provide easy access to essential services receive additional recognition and points. However, these indicators fall into several categories rather than one category that addresses only the social aspect. This diminishes the scope and clarity of these frameworks. Unlike SBTool, which places particular emphasis on ensuring that projects address social aspects, respect cultural heritage, and promote social cohesion (see Table 1.9). the economic category, SBTool has the advantage of covering a broader range of economic aspects and incorporating financial considerations more comprehensively than BREEAM and LEED in

their assessment frameworks (see Table 1.9). This broader focus on the economic aspects of SBTool can provide a more comprehensive view of the financial implications of sustainable building practices.

Table 1.9. The comparison of social & economic categories in selected assessment tools.

	Socio-Economic Indicators	BREEAM	LEED	SBTool
Social Category	Functionality and Usability			*
	Flexibility and Adaptability			*
	Durability and Reliability			*
	Controllability of system	*	*	*
	Maintenance of performance	*		*
	Impact on quality of service and adjacent property			*
Economic Category	Construction cost			*
	Life cycle cost			*
	Operating & maintenance cost	*	*	*
	Investment risk			*
	Affordability of residential rent			*

1.4.4 Researchers Sustainability Assessment Frameworks

There are many individual experiences of creating sustainability assessment tools considering specific regional contexts. These research works demonstrate how different assessment methodologies and distinct criteria can efficiently and appropriately address the sustainability of buildings. This subsection will describe some of these research works highlighting the objectives, tool used, and the comments, as illustrated in Table 1.10.

Table 1.10. Sustainability assessment frameworks developed by researchers.

	Author	Objective	Tool Used	Comments
1.	(Salah et al., 2023)	Develop a framework for assessing the sustainability of construction projects.	Comprehensive literature review for SAT and research.	• Comprehensive of the three pillars of sustainability. • Ignoring the local context and regional specificity.
2.	(Alhilli & Burhan, 2021)	develop a system to implement sustainability ideas in school building in Iraq	BREEAM, LEED, PBRS, AlSa'fat, SBTool^{pt,} and Experts' opinion.	• The study assesses environmental sustainability in school buildings, ignoring socio-economic indicators.
3.	(Khan et al., 2021)	Develop a holistic framework of building rating tools for Pakistan's Local Context	SEED, Green Star, LEED, BREEAM, CASBEE, and DBNG.	• The framework considers the five stages of the building life cycle. • The framework did not specify the type of building
4.	(Šuman	Develop a new	LEED,	• Scarcity of research on

	et al., 2020)	framework for renovation existing office buildings in the city of Maribor in Slovenia.	BREEAM, and DGNB	sustainable renovation in public buildings. • Ignoring the local context and regional specificity.
5.	(T. Saraiva et al., 2020)	Adapt the SBTool methodology for the Sustainability Assessment of High School Buildings in Portugal.	LEED for Schools, BREEAM Education, and SBTool^{pt}	• The first sustainability assessment of Portuguese school construction. • The SBTool can be easily adapted to assess basic education institutions.
6.	(Alawneh et al., 2019)	Identify assessment categories and indicators for sustainable non-residential buildings in Jordan.	LEED, BREEAM, Green Star, CASBEE, Green Mark, GBI, and individual frameworks.	• New and innovative integrated weighing (a combination of AHP and RII methods), which maintains the focus of the Sustainable building assessment framework.
7.	(Harb et al., 2019)	Develop guideline to assess sustainability of Schools (new and existing schools) in Egypt.	Cyprus's and Canada's Eco-School program, Ireland's Green-Schools program, and LEED for Schools.	• The first sustainability assessment of Egyptian schools. • The same framework for the new and existing school, which is ineffective. Because the indicators are different in these two cases.
8.	(Akhanova et al., 2019)	develop a sustainability assessment framework for commercial building in Kazakhstan.	LEED, BREEAM, CASBEE, and SBTool.	• The framework lacks clear and detailed social indicators.
9.	(Olakitan Atanda, 2019)	Develop a social criteria framework for building.	LEED	• An attempt to build a indicators structure to assist the current GBAT towards achieving Social Aspect in Buildings.
10.	(Mahmoud et al., 2018)	develop a global sustainability rating tool for existing buildings, in Canada and Egypt.	LEED, BREEAM, and Green Star.	• Using a multilevel weighting scheme. • The framework lacks social & economic indicators.
11.	(Shad et al., 2017b)	propose a new set of comprehensive factors to assess Iranian office	BREEAM, LEED, CASBEE and GBTool.	• The framework has a comprehensive economic category.

		buildings		• The framework lacks social indicators.
12.	(Banani et al., 2016)	Develop a framework for domestic sustainable non-residential building assessment criteria for Saudi Arabia.	BREEAM, LEED, Green Star, CASBEE, and Estidama.	• Environmental factors account for 72% of the total valuation weight. • Social factors are a key component of this study.

1.5 Research Gaps

Scientific gaps identified in sustainability assessment include the complexity of constructing assessment criteria, considering economic aspects, assessing social services, and the flexibility of adapting to local contexts. Many criteria and indicators in assessment frameworks can lead to complexity and challenges in assessing and organizing information. For example, LEED and BREEAM have about 70 indicators, and SBTool has more than 150. Simplifying the assessment structure by emphasizing a common goal, such as competence in a built environment, can simplify the criteria and improve the accuracy of the assessment. This streamlined approach allows for a more focused assessment of key sustainability issues and makes it easier for planners and developers to prioritize actions that align with sustainability goals.

Financial and social aspects are critical in promoting sustainability and affect both developed and developing countries. By incorporating financial metrics into assessment frameworks, such as life-cycle cost analysis and return on investment, projects can better understand the economic benefits of green building strategies. In addition, financial incentives and grants for sustainable projects can encourage their widespread adoption. While the frameworks touch on social inclusion measures, there is still room for more robust metrics that measure the impact of construction projects on vulnerable and marginalized populations. Greater assessment of social inclusion can lead to more equitable and inclusive developments, but LEED and BREEAM have partially excluded financial and social elements from their analytical structures. So did SBTool, but it was clearer to define these two categories (see Table 1.11).

Table 1.11. The environmental, economic, and social aspects in selected sustainability assessment tools (Atanda & Öztürk, 2020; Illankoon et al., 2017).

Tools	Environmental Aspect (%)	Economic Aspect (%)	Social Aspect (%)	Others (%)
BREEAM	72.1 %	3.7 %	18.6 %	5.6 %
LEED	80.0 %	1.8 %	11.0 %	7.2 %
SBTool	64.9 %	2.5 %	17.1 %	15.5 %

Adapting assessment frameworks to local contexts is critical. Developing tools that can be modified to suit specific regional conditions, such as climate or policy priorities, ensure that frameworks remain relevant and effective across different geographies. In addition, incorporating feedback and lessons learned from diverse regions can lead to more

comprehensive and universally applicable assessment tools. By addressing these scientific gaps and continuously improving sustainability assessment frameworks, they can play a more significant role in driving sustainable practices in the construction industry. Emphasizing collaboration, customization, and a holistic understanding of sustainability will allow these tools to evolve and support the broader goal of creating a more sustainable built environment for current and future generations.

1.6 Conclusion

This literature review highlights the importance of sustainability in the construction sector, especially in public buildings. It has highlighted the barriers that exist in implementing sustainable practices in this sector. One of the main obstacles is the lack of availability of research on this topic, which requires new developments in this area. The role of known rating systems and the potential of new research-based systems to promote sustainable practices are highlighted. As noted earlier, public buildings serve the community and should be sustainable. This goal requires the development of specific frameworks and tools to help policy makers and communities improve the sustainability of public buildings. This study aims to contribute to this goal, focusing on schools as a pillar of the education system.

The next chapter will explore the relationship between sustainability and education and how sustainability contributes to the growth and success of educational institutions. It will also highlight the role of education in promoting sustainability awareness and practices within the community.

Chapter 2 Sustainability and Education Nexus – Literature Review

2.1 Introduction

Linking sustainability and education is a critical interface that addresses pressing global challenges such as climate change, biodiversity loss, energy crises, and social inequality. These interconnected issues require urgent attention from governments, businesses, NGOs, and communities. At the heart of sustainability is a complex web of societal values that encompasses justice, freedom, self-determination, global well-being, and responsibility to future generations. As a result, sustainability is increasingly recognized as an essential goal that requires a profound shift in perspectives and attitudes.

Experts agree that achieving sustainability requires a fundamental change in lifestyle, and this change depends on education. The education system plays a central role in providing the awareness, knowledge, and skills individuals need to embrace the principles of sustainability. Therefore, integrating sustainability into the learning process is essential for progress. Educational institutions should enable learners to better understand sustainable society issues and develop competencies to create innovative economic, social, technological, cultural, and environmental solutions. A paradigm shift in the education system is essential to enable this comprehensive education for sustainability.

The realization of sustainable development depends on the active participation of education in all its forms and sectors. Figure 2.1 illustrates the relationship between sustainability and education, which has two sides. First, education is essential to the success of sustainability efforts. Second, sustainability requires a transformation in education itself, through an expanded, renewed, and purposeful vision of education.

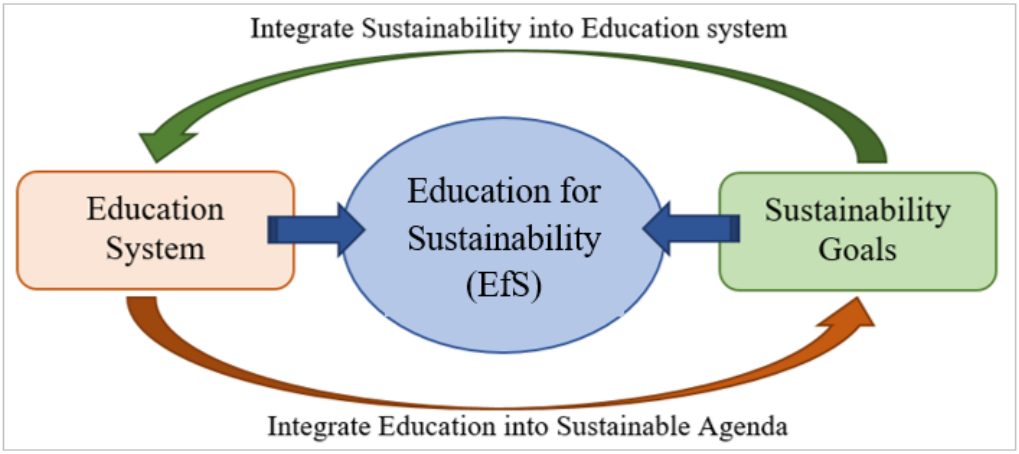

Figure 2.1. Sustainability and Education nexus (Source: Author).

In the next sections, we will explore the role of sustainability in the education system, emphasizing that sustainability is not just an optional add-on, but a critical key to addressing humanity's challenges through informed solutions and collective responsibility. It discusses how sustainability can provide an innovative approach to reshaping education that focuses on

its social, environmental, and economic impacts. The third section describes the evolution of Education for Sustainability (EfS), its core principles, and the role of education stakeholders in promoting and implementing EfS standards. In addition, this section takes a closer look at the role of education in promoting social, environmental, and economic sustainability. The final section introduces the concept of sustainable schools and outlines its basic principles for implementation. These principles prioritize the well-being of all involved in education and emphasize self-care, respect for others (culture, rights, and justice), and environmental awareness. The sustainable school approach includes integrating sustainability goals into the curriculum, implementing sustainable practices in the use of energy, water, waste, and biodiversity, and ensuring active participation, especially by students.

2.2 Role of Sustainability in the Education System

Sustainability is the key to a better future. On the other hand, education is the most effective means to fight poverty, social exclusion and inequality. At the same time, education promotes people's active participation in their societies as they learn to respect and live in a world characterized by diversity and pluralism. Therefore, it is important to study sustainability. In this section, we address how sustainability promotes and supports education, the strategies used to do so, and the importance and impact of sustainability in education on society.

Global efforts to deal with threats to economic stability, environmental damage, and a growing number of social problems are clear indications that current global trends are not sustainable (Silva et al., 2020). According to (Griswold, 2017), policies and actions are needed to protect our way of life and maintain the integrity of the world's ecosystems and biodiversity through education. This goal is reinforced by the UN Sustainable Development Goal SDG 4 on education and the education goals included in other SDGs. The overarching 2030 Agenda for SDG 4 commits to “ensure inclusive and equitable quality education and promote lifelong learning opportunities for all”." It (see Figure 2.2) includes seven targets and three implementation models.

SDG 4 ensures quality and easy access to education and other learning opportunities for children and youth. It aims to provide an essential component for the acquisition of valuable knowledge and skills in a learning environment. Therefore, it is critical to mobilize targeted national, regional and global efforts to achieve SDG 4 on education. To achieve this, the following strategies are proposed:

- Improve education policies and the way they work together.
- Ensure highly equitable, inclusive, and quality education systems for all.
- Ensure monitoring, follow-up, and review of all targets.
- Achieve effective and inclusive partnerships.
- Mobilize resources for adequate financing for education.

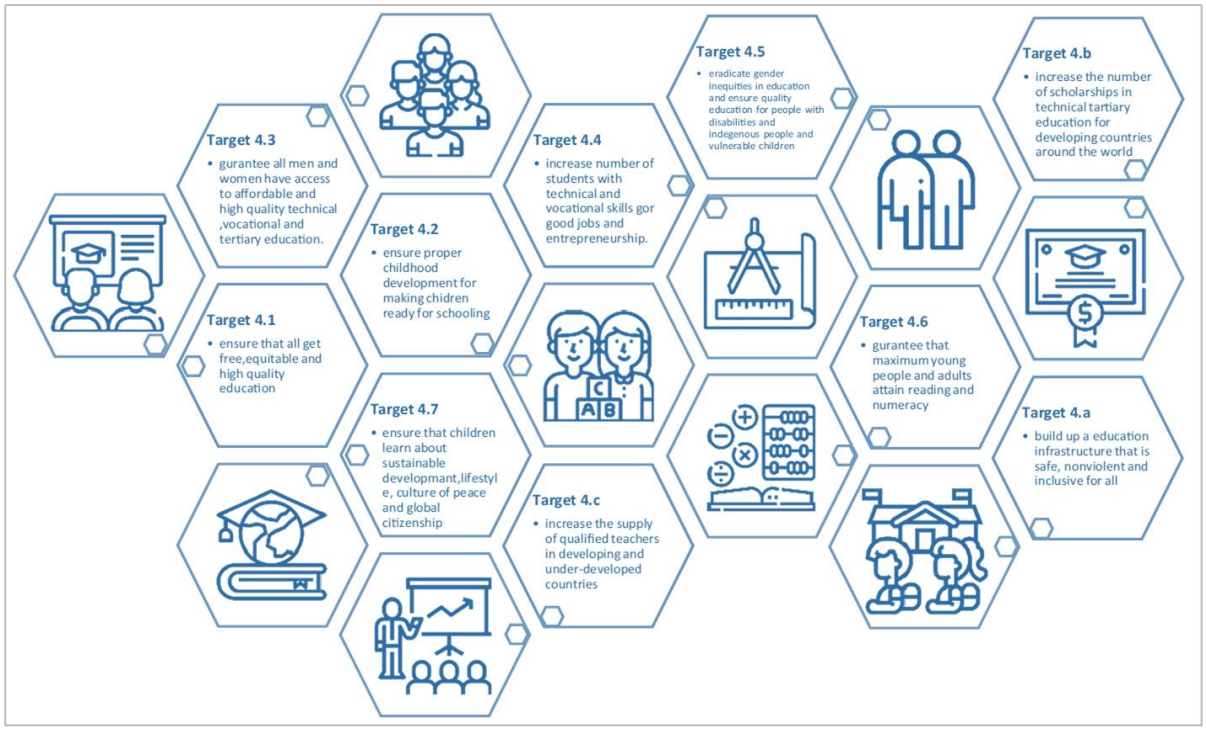

Figure 2.2. Sustainable Development Goal (SDG) 4 and its components for education (Source: (Saini et al., 2022)).

Unfortunately, education systems are among the most affected in the Covid 19 crisis worldwide (Saini et al., 2022). More than 90% of students worldwide are affected, with an estimated 1.5 billion children and youth lacking access to education (UN News, 2020). Although the impact of COVID -19 has been significant, it has helped create new types of education systems. Many educational institutions have tried to sustain programs through online and e-learning education. This confirms the importance of developing the education system and finding new alternatives that are appropriate to the current development and support sustainability in its three pillars.

The importance of sustainability goals in the education system is that they teach current students and future leaders about the three pillars of sustainability (social, environmental, and economic), which are multi-faceted and complex. It is important to understand how they influence and develop each other. Therefore, in many countries, the education system is the most important factor in the overall economic and social development of the country. The following subsections illustrate the implications of the three aspects of sustainability in education.

2.2.1 Social Aspect in Education

Education is a subsystem of the broader social system. These systems include educational authorities, institutes, colleges, and schools. Education is usually considered one of the most important social institutions, as it forms the present and future of any society (ALTAN, 2020). Without it, all other institutions, such as the family, politics, health care, religion, and the economy, would be meaningless and incomplete. This strong relationship between society and education confirms that both influence each other, either negatively or positively (Sekhar Reddy & Sailakshmi, 2018).

Sustainability in education is expected to advance social progress through four different but interrelated purposes (Spiel et al., 2018), which are:

1. Education develops civic skills, which is invaluable for the individual, to enable meaningful participation in civil society and politics and for society, to benefit from an informed and engaged citizenship.
2. Education develops productive skills, which are valuable to the individual to progress in the labor market and for society to enhance and sustain prosperity and competitiveness in a global economy.
3. Education develops human skills and interests, which are useful for the individual, enabling personal prosperity and society since the expansion of knowledge and human realization, are invaluable.
4. Education can be a means of achieving justice and greater social inclusion, or in its absence, poorly presented or unfair distribution, it can be a means of injustice and increasing social exclusion.

From the above, we conclude that education as a social sub-system has a well-defined goal, purpose, and function to bring about positive and sustainable societal changes. In general, the education system has six sustainable social criteria, as shown in Table 2.1. These criteria promote social equity, cultural identity and value, participation of stakeholders in decision-making, ease of accessibility and mobility, health and safety, and continuous innovation in the education system. Achieving these criteria helps in sustaining education to fulfill all its goals on the social level. They will be the basis on which we build our framework for assessing the sustainability of the school system.

Table 2.1. The sustainable social criteria in the education system.

No.	Social Criteria	Description	Reference
1.	Social Equity	Education is for all people without any gender or social status restrictions.	(Atanda & Öztürk, 2020)
2.	Culture Value	Education system contributes to maintaining the local community culture and historical value, in addition to promoting the local community's needs.	(Rohman & Hidayat, 2019)
3.	Participation and Involvement	The local community is involved in the decision-making process.	(Findler et al., 2019)
4.	Accessibility and Mobility	Integrate suitable coverage of transportation services, modes of non-motorized mobility, or access to public services.	(Fatourehchi & Zarghami, 2020)
5.	Health and Safety	Involve the practices that protect education stakeholders' lives, and take into consideration, for example, safety training programs, health and safety equipment, and health and safety plans.	(Sierra et al., 2018)
6.	Innovation	Education system can always adapt to changes in the surrounding community.	(Rohman & Hidayat, 2019)

2.2.2 Environmental Aspect in Education

From an environmental perspective, educational buildings are considered one of the most important facilities in the community, as students spend about 30% of their time in class (Burman et al., 2018). This means that educational buildings are the second most important indoor environment after children's homes. Moreover, the occupancy rate of a school is usually much higher than that of all other buildings (T. S. Saraiva & Almeida, 2018). Therefore, schools must have indoor comfort that does not affect children's health and mental performance. (T. S. Saraiva & Almeida, 2018) illustrates that students' grades have decreased proportionally to the increase in students' complaints about environmental quality and social comfort factors.

Therefore, several studies highlight the importance of sustainability and the reasons why educational institutions try to make their environment more sustainable. (Filho et al., 2015) have shown that many educational institutions are becoming increasingly aware of their impact on the environment and society and are trying to understand the impact of their activities. (Al Shboul, 2018) claimed that sustainable school is one of the biggest challenges of the 21st century, especially after the increasing number of students due to the increasing demand for education, in addition to the increase in the number of school days and the time that the student spends in school every day. Therefore, serious measures are recommended to increase environmental sustainability in educational buildings.

Sustainable education must consider the six criteria listed in Table 2.2: Energy Efficiency, Greenhouse Gas Emissions, Water Efficiency, Indoor Environmental Quality and Surrounding Buildings, Waste Management, and Site Selection and Infrastructure. Achieving these criteria improves the environment at the building, local, and global levels.

Table 2.2. The sustainable environmental criteria in the education system.

No.	Env. Criteria	Description	Reference
1.	Energy Efficiency	Education system seeks to improve energy efficiency, energy savings, energy consumption, and energy production in education buildings.	(Akhanova et al., 2019; Mahmoud et al., 2018)
2.	Water Efficiency	Education system seeks to improve water efficiency, water savings, water consumption, and water collection in education buildings.	
3.	Environmental Quality	Education system seeks to improve thermal comfort, air quality, visual comfort, and acoustic comfort in education buildings.	
4.	Waste Management	Education system seeks to efficient use of materials, solid waste management, and liquid waste management in education buildings.	
5.	Greenhouse Gas Emissions	Education system seeks to reduce the greenhouse gas emissions emitted from education buildings to improve the global environment.	
6.	Construction Site	Education system seeks to have good land use,	

	Selection and Infrastructure	low-impact site construction, access to socio-economic facilities, access to public and ecological transport, greenspace, etc.

2.2.3 Economic Aspect in Education

Education is the most important determinant of economic growth, employment and profits in society. Neglecting the economic dimension of education will affect future generations, with serious consequences for poverty, social exclusion, and the sustainability of social protection systems (Woessmann, 2016). (Mutton & Ciriello, 2021) shows that ten dimensions shape a country's economic well-being, education and the general skill development of the population, which are the most important factors when it comes to long-term economic sustainability. Moreover, compared to investments in other aspects of a country's economy, such as public finances and economic institutions, education is the most important lever in promoting long-term economic development.

The relationship between public spending on education and economic growth can be complicated and difficult to measure because the effects of education are often indirect and can take many years to fully unfold (Appiah, 2017). Nevertheless, significant historical data demonstrate a positive correlation between quality of education, quantity, enrollment, and economic growth (Psacharopoulos & Patrinos, 2018). As shown in Table 2.3, the average return on investment in education is 9%. Moreover, for every $1 spent on education, economic growth of $10 to $15 can be achieved (UNESCO, 2012). Consequently, it can be said that the quality and quantity of education are important drivers of economic growth and should therefore be a priority for government spending.

When we talk about the role of education system in improving the economic level in a country, we talk about many aspects that can be independent and sometimes not independent from the social and environmental aspects. But these aspects can be classified into two main criteria of economic progress, as shown in Table 2.4, namely: economic and local development and employment. The education system strives to improve and develop the economy of the community by creating different projects, and of course it helps to create new jobs for the community.

Table 2.3. Private Returns to schooling by region. (Source: (Psacharopoulos & Patrinos, 2018))

Region	The overall rate of return (%)	Mean years of schooling
Latin America and Caribbean	11.0	7.3
Sub-Saharan Africa	10.5	5.2
East Asia and Pacific	8.7	6.9
South Asia	8.1	4.9
Advanced Economies	8.0	9.5
Europe and Central Asia	7.3	9.1
Middle East and North Africa	5.7	7.5
World average	8.8	8.0

Table 2.4. The sustainable economic criteria in the education system.

No.	Economic Criteria	Description	Reference
1.	Economy and local development	Education seeks to improve and develop the economy of the community	(Sierra et al., 2018)
2.	Employment	Education seeks to create new jobs for the community	(Rohman & Hidayat, 2019)

The framework of SDG 4 aims to ensure social cohesion, economic prosperity, and environmental protection. Education, research, and innovation are essential to achieving these sustainable goals, and universities and schools are major contributors. This is because universities and schools are in direct contact with young students and newer generations who will become future employees and future employers. Therefore, modifying educational programs and curricula is critical if we want to have open and sustainable-conscious generations which aspire to sustainability and contribute to the development of society. This requires some change in the education system and the school system, as shown in the following sections.

2.3 Education for Sustainability (EfS)

Education is internationally recognized as fundamentally important for addressing critical global challenges. Through education and lifelong learning, we can achieve a lifestyle based on economic and social justice, environmental integrity, sustainable livelihoods, and strong values that promote social cohesion and democracy. These goals lead to the promotion of the concept of Education for Sustainability (EfS). This section illustrates Education for Sustainability and its goals, the principles underlying EfS, and its implications for students, teachers, and the community. It also presents comprehensive strategies for achieving the three pillars of sustainability through education in the community.

Education for sustainability is a "whole system of inquiry" that connects teaching and learning practices to the content, skills, and knowledge students need to participate powerfully in creating a sustainable future. It is important to reorient education and the way we live and work for a sustainable society and future (Engdahl, 2015). This is done by informing and raising awareness, but more importantly by empowering people to develop and implement solutions. EfS is ambitious because it is not just about adding new information or topics to the curriculum so that people learn about sustainability. Rather, it is about how we “do” education and “respond” to the demands of sustainability by rethinking our methods, revising our courses, reprioritizing, and realigning our communities of practice.

The goal of EfS is to increase awareness and knowledge of sustainability issues and empower students and younger generations to think critically, innovate, and find solutions for a more sustainable lifestyle. It empowers everyone to make informed decisions about environmental security, economic viability, and a just society for current and future generations. In addition,

EfS has a significant impact on students, teachers, and communities, resulting in numerous positive and lasting benefits (Cloud, 2014). That is:

Impact of EfS on students:	• Improve student learning and achieve standards • Reinforce attitudes toward learning • Produce better behavior and attendance • Develop a greater awareness of society and a greater appreciation for the democratic process • Produce statistically significant increases in the strength of students' attitudes about civic engagement • Provide a safe and secure space in which children can take risks and develop active participation skills.
Impact of EfS on teachers:	• Supports new and veteran teachers in achieving strong academic outcomes for their students • Produces meaningful effects on teacher attitudes
Impact of EfS on the community:	• Improve whole school cultures • Promote meaningful relationships between the school, parents, and the community • Model of actions and attitudes that promote sustainable living • Improve air quality, reduce waste, and reduce energy and water use

Education for Sustainability is based on seven principles. These core EfS principles can be used to promote innovation in existing curricula and to develop educational strategies. In addition, they can serve as the basis for indicators to improve the quality of teaching and the education system. The EfS principles presented in Table 2.5 fit within the United Nations Development Program's framework for implementing Goal 4 of the Sustainable Development Goals (UNDP, 2015).

There is a significant gap between society's aspirations for a healthy and sustainable future and the knowledge, skills, and attitudes taught in preschool schools. (Figueiró et al., 2022) noted a mismatch between the importance of EfS and the actual implementation of its integration in the education system and schools due to its multiple characteristics and complexity. Therefore, the efforts of governments, local communities, nongovernmental organizations, financial organizations, and other stakeholders in the education system need to be integrated and coordinated to achieve sustainability goals and EfS principles.

This leads to the importance of clarifying the roles and responsibilities of each education stakeholder in promoting sustainability through education, as discussed in subsection 2.4.1. The following subsections explain the role of education and its actors in promoting and implementing each of the pillars of sustainability: social, environmental, and economic.

Table 2.5. The education for sustainability principles (Source:(UNDP, 2015)).

1. **Education for all and lifelong learning**
Education and learning must begin at birth, continues throughout life, include people of all ages and backgrounds, and takes place in all possible places of learning, formal and informal, in schools, workplaces, homes, and communities.
2. **Transformation and change**
EfS is not just about providing information but also about providing people with the skills, abilities, and opportunities to engage with the world in an informed manner. It helps people to plan toward sustainability within an organization, industry, or community.
3. **Systems thinking**
EfS can help us to understand the connections between environmental, social, economic, and political systems. It also helps us identify links and relationships within a particular system so that we can achieve beneficial outcomes for the whole system. It also helps us identify links and relationships within a particular system so that we can achieve beneficial outcomes for the whole system. It shifts thinking from “things” to “processes”.
4. **Envisioning a better future**
EfS engages people in imagining preferred visions of a sustainable future. The process of envisioning leads people to take responsibility for a sustainable future and to find a renewed and balanced approach to the way they interact with each other and with the environment.
5. **Critical thinking and reflection**
EfS enables people to investigate new ways of thinking and behaving, make informed decisions, and create alternatives to view choices. It values the capacity of individuals and groups and helps them interact with the world and strive for a more sustainable life.
6. **Participation**
The concept of participation goes beyond consultation, to empowering stakeholders by directly involving them in the sustainable decision-making process. This creates a greater sense of ownership and empowerment, both of which is very important in taking action.
7. **Genuine partnerships for change**
Partnerships are a driving force toward change. They provide a means to bring together individual and group endeavors across local and global communities. They promote learning how to work together to build a common vision for the future by bringing together knowledge, technology, and resources.

2.3.1 The Role of Education Stakeholders

In the world of education, stakeholders can be individuals, groups, or institutions that have an interest in the project and can influence and be affected by the outcomes of the education system (Francisco de Oliveira & Rabechini, 2019). All stakeholders should have easy access

to education data and use it to answer questions that need to be answered. The main goal of stakeholders is to ensure that students receive a quality education. This helps build a stronger community by preparing students to be successful members. All stakeholders play an important role as part of a team working toward the success of education for sustainability principles and goals.

The education stakeholders list includes internal and external stakeholders as presented in Figure 2.3. The school system is the internal stakeholder, which includes those who work within the school system daily, including students, teachers, and school administrators. While the external stakeholders, those who do not work within the school system daily, can be dependent (central authorities) and independent stakeholders. The central stakeholders have a direct impact on decisions in schools and on outcomes as well. In addition, the power with internal stakeholders (school system) is mutual and influences each other. Nevertheless, independent stakeholders have an impact on schools, but indirectly. Communication is also done through central stakeholders, not directly with the school system.

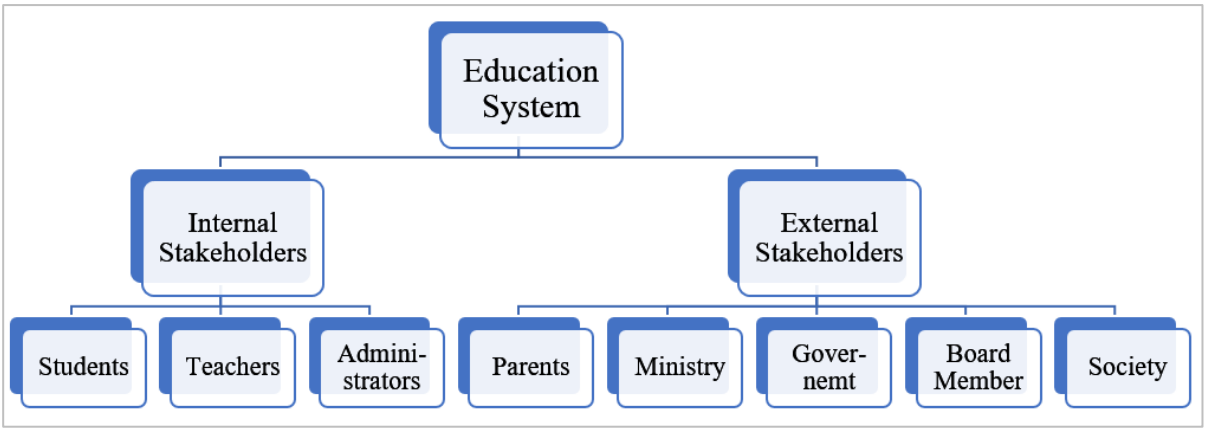

Figure 2.3. The stakeholders in the education system. (Source: Author)

As you can see in Table 2.6, each of the educational stakeholders has roles and responsibilities in addition to interests and goals. However, they all share one main goal: to ensure that schools provide a high-quality, equitable education for all (Marshall, 2018). By consulting a broad range of stakeholders, policymakers can make more effective decisions that reflect the desires of community members. At the same time, this helps ensure that school initiatives contribute to sustainable community development.

These stakeholders play a role at all educational levels of formal, non-formal, vocational, and community education. Addressing the value and place of EfS as an educational quality concern requires stakeholder engagement at many levels. In this study, however, the focus is on the school-level stakeholder (internal stakeholder). This means that the school level (formal and non-formal) and the roles and responsibilities of students, teachers, and school administrators in promoting sustainability principles and supporting the system of education for sustainability are highlighted in Section 2.5.

Table 2.6. The roles and responsibilities of the education's internal and external stakeholders (Source: Author).

Type of Stakeholders		Description	Role	Responsibility	Expectations
Internal Stakeholders	Student	The primary stakeholders in education.	Learning, and respecting all school staff.	• To treat others fairly and respectfully, and • To be supportive of all members of the school community.	A good education to receive the knowledge and skills to be successful in life and to be part of a sustainable community
	Teacher	The interactive role in the educational process with students.	Teach children everything they need to know	• Promote school values and sustainable principles, • Meet the learning needs of students, • Create a positive learning environment in the classroom, and • Enhance student and parent support.	Improving their job through improving students' learning and achievements.
	School Administration	The principal, assistant principal, and other school leaders.	The management of schools and administrative tasks.	• Supervising teachers and other school staff, • Overseeing the school's teaching and curricula and making decisions about their school's improvement plan, and • Listen to other stakeholders when making strategic decisions so that schools reflect the values of sustainability.	Improving academic performance and student discipline
External Stakeholders	School Board Member	Members of the community elected, usually consist of a group of parents, the business community, and municipality members.	Improving policy that helps implement changes that will support the education system and sustainability principal	• Ensure high-quality teaching and learning materials for students in their school district, • Ensure comfortable working conditions for teachers and all school staff, and • Interact with different local authorities.	Increasing awareness and trust among the participating parties to facilitate the decision-making process and improve the policies that support the education system
	Parent	The group consists of parents and grandparents	Provide additional resources for the school to assist in student achievement that may be influencing the school's overall success.	• To guide their child in adhering to the school's guidelines, • To be available for parent-teacher conferences and other consultations, and • Promote a comfortable environment for children outside of school.	Their children receive a high-quality education and knowledge.

Ministry	Ministry of Education and Higher Education	Specify the laws and regulations that govern schools	• Collaborate with schools, other government agencies, and NGOs to formulate effective programs and practices, and • Supporting teachers to achieve the desired results of education.	Clear education, skills, knowledge, and values suitable for society.
Government	Different governmental structures like, for example, the Ministry of Finance, the Ministry of Health,	Monitor the overall educational strategy, and fund the education system	• Promote school health and nutrition advocacy, • Support stakeholder engagement, • Develop partnerships with key parties, • Provide Teachers' salaries, and • Offer scholarships	Clear and fruitful cooperation between the different parties to achieve the maximum benefit from educating citizens.
Society	Community members, the business community, and different professionals, such as social workers and volunteers.	Convey the right values and sustainable attitudes to youth	• Recognize the diversity of abilities and talents, • Provide bursaries to students and teachers, and • Provide support to families and students who need help.	A solid educational program that helps students become smart, confident, determined, and successful

2.3.2 Education for Social Aspect

The social aspect of EfS is about ensuring that all people have a good and equitable foundation for living with dignity and have the opportunity to impact their lives and communities (UN News, 2020). Social sustainability can encompass a wide range of aspects, from more general aspects such as social justice, improved quality of life, and the well-being of future generations, to more specific goals such as promoting people's democratic right to participate, take action, and influence their lives (Boldermo & Ødegaard, 2019).

Education is one of the most powerful tools for social sustainability change. Educational institutions can respond to social change in a variety of ways: They need to change staff practices, modify teaching methods, develop new skills to change students' attitudes toward social problems, and create programs and courses that help solve difficulties that arise from social change (Sharma & Monteiro, 2016). To achieve this requires the collaboration of educational stakeholders, especially the government and the community. They play a key role in setting education policies that pave the way for change and improvement.

To bring about change in social development through education, government structures must be changed. The government must make the best use of the political, technical, financial, and managerial capacities in the education system, as well as community engagement, to achieve the ultimate goal of a sustainable community: productivity, resilience, inclusivity, and sustainability (Ofei-Manu et al., 2018). The government must also provide relevant national sustainability initiatives to encourage and fund all stakeholders to promote quality learning

opportunities for all. In addition to creating collaborative projects with other countries, this involves sharing knowledge, information, resources, and exchange programs at the school and college levels. This requires the implementation of a system to monitor and evaluate the success of social sustainability education activities in order to improve the level of social sustainability in the educational community.

Social responsibility is one of the hallmarks of a democratic society, a society that encourages its members to be actively engaged citizens, i.e., responsible citizenship. However, this approach is rarely systematically discussed or adequately integrated as an educational goal (Abu Hussain & Gonen, 2017). Education is mentioned as one of the priority areas to promote social responsibility. Therefore, social responsibility should be an integral part of the educational process from kindergarten through primary and secondary schools to universities and teacher training colleges (Abu Hussain & Gonen, 2017).

Developing a sense of social responsibility in children is of great importance. This is because people with a sense of responsibility have clear goals; they work harder, show higher loyalty to their tasks, are less anxious, and show better performance toward sustainability (Buğdayci, 2019). Therefore, they are in demand and liked in their environment. This is necessary for the development of society and the increase of production in all fields. Therefore, according to (Filiz & Demirhan, 2019), cooperation between school administrators, teachers and families as part of the community is necessary to strengthen students' responsible behavior and contribute to its improvement.

Social responsibility describes how education can contribute to the social and environmental well-being of communities, both at the school and state levels. Social responsibility is integrated into all aspects of school life, including instruction, research, and public events and activities. It covers a variety of activities such as:

- Community participation.
- Equality, diversity, and inclusion.
- Sustainability.
- Humanitarian activities.

To this end, teachers should provide opportunities for students to demonstrate behaviors such as taking responsibility, participating, helping, completing tasks, and coaching. (Filiz & Demirhan, 2019) emphasize that responsibility education is one of the most important school subjects because values education will make an important contribution to the development of individuals' identity and level of social responsibility. They believe that any curriculum must teach social responsibility in order for students to develop successful identities. Therefore, due to the inadequacy of exam-centered education in schools, new curricula are needed to teach students responsible behaviors.

We can conclude that internal education stakeholders can collaborate with external stakeholders, especially the government and the community, to add value and promote education initiatives for social change and development. This will help highlight the

characteristics, benefits, limitations, and applicability of social education (such as community participation, social responsibility, quality, equity, etc.). A better understanding of these points and good governance will promote the social development of society.

2.3.3 Education for Environmental Aspect

The current ecological crisis is unacceptably affecting the living environment. Given the enormity of this phenomenon, decision makers at the global level are trying to take decisive and urgent measures to protect nature in order to preserve the human environment; these measures are also adopted by the educational system (Marouli, 2021). Therefore, people pay more attention to environmental education or environmental issues in management education (S. Liu & Guo, 2019). Environmental education is expected to enrich people's environmental values, thus changing people's attitude.

Environmental education is a way for individuals to explore environmental issues, participate in problem solving, and take action to improve the environment (Mohiuddin et al., 2018). In this way, individuals can develop a strong understanding of environmental issues and have the knowledge and skills to make informed and responsible decisions. There are five components of environmental education, which are:

- Knowledge and understanding of the environment and environmental challenges.
- Awareness and sensitivity to the environment and environmental challenges.
- Skills to identify and help solve environmental challenges.
- Attitudes that care about the environment and the motivation to improve or maintain environmental quality.
- Participate in activities that lead to the solution of environmental challenges.

According to (Boca & Saraçli, 2019), education can promote environmental aspect through: education for the environment, education in the environment, education about the environment, and education to the environment, as shown in Figure 2.4.

1. Education IN the Environment:

Educational institutions need to adapt their curricula, create a new kind of education to foster students' passion for environmental education by using skills and laboratories, developing their services, and conducting hands-on activities in nature (Abdullah et al., 2018). For example, hands-on lessons should teach them about plants, the effects of the seasons on the ecological situation and community behavior, cleaning procedures in parks and rivers, and planting and recycling trash. Creativity can be used to create modern fashion, art drawings, or designs from trash.

2. Education FOR the Environment:

Educational institutions have to encourage students to keep the indoor environment (campus) in good shape because most of their time is spent in school, which is their learning space.

Therefore, they can use non-polluting energy, for example, solar and wind energy. They can use green products, such as recycled paper and plastic, etc.

3. Education ABOUT the Environment:

Educational institutions should create initiatives for in-depth discussions between students and experts to clarify, critique, and compare certain facts or attitudes toward nature and the environment (Erhabor & Don, 2016). They should help students practice certain situations and find solutions to protect and preserve the environment for the future. They should use the media to introduce environmental disasters and solutions, and establish an online group to develop various voluntary activities on environmental problems.

4. Education TO the Environment

Teachers should encourage students to maintain their sustained opinions, respond to environmental problems in everyday life, participate in critical situations and find solutions. Here, online platforms can be used to create a virtual environment and model some spaces for a risk situation, developing ethics and environmental impacts (Q. Liu et al., 2019).

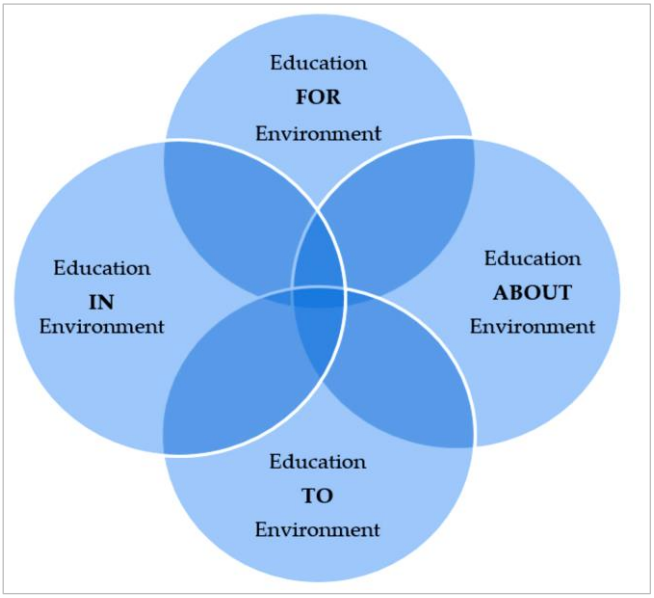

Figure 2.4. Education for environmentally sustainable aspect (Source: (Boca & Saraçli, 2019)).

It is increasingly clear that people with higher education tend not only to care about the environment, but also to engage in actions that reinforce and support decisions to protect it. For example, an analysis of the Global Warming Citizen Survey in the United States (2021) showed that the higher the respondent's education level, the more active he or she was in supporting environmental policy, participation, and pro-environmental behavior. Such pressure is an important means of getting governments to change agreements and policies, especially in the education system.

2.3.4 Education for Economical Aspect

In the last three decades, economic research has established the importance of education as a crucial factor in economic development (Maneejuk & Yamaka, 2021). The development of

human skills and knowledge of the population or labor force is called education. Education is considered human capital because of its contribution to economic development, and education expenditures are considered investments in people and human capital. However, economic progress can be achieved not only by increasing the number of educational opportunities, but also by improving the quality of the type of education provided (Pekkolay, 2021).

In addition, economies are experiencing rapid changes driven by technological progress. This will increasingly require education systems with strong technical and vocational education and training (TVET), higher education, and lifelong learning to retrain and educate people. Therefore, a cross-sectoral approach must be taken to address the importance of the relationship between basic education, TVET, and higher education. Higher education also plays a critical role in creating decent work by promoting innovation and strategies for sustainable economic growth through the production of research and collaboration with government and the business sector (Žalėnienė & Pereira, 2021).

This highlights the importance and role of business and industry in strengthening the role of education for sustainability, especially in the economic aspect. Businesses and industries can support educational programs and experiential learning, promote the knowledge and skills of their employees, and collaborate with community stakeholders. The following can be a strategy for business and industry to promote education for sustainability:

1. Collaborate with partners to develop education for sustainability and link it to job skills and career paths. Businesses and industries can help integrate sustainable issues and visions from business into the design of courses, programs, teaching, and experiential learning opportunities.

2. Educate and engage other stakeholders on EfS, from government, industry bodies, professional associations, policymakers, and non-government organizations. Businesses can benefit from demonstrating how working on sustainability is central to their daily work and essential to a thriving society, inclusive economic growth, and human progress.

3. Integrating EfS principles into business schools. Given the great impact of business schools on current and emerging business and industry leaders, it is very important and essential to integrate EfS principles into business school curricula, including MBA programs and short courses.

4. Business, industry, and business school partnerships for sustainability. To enhance the above integration and create demand, partnerships between business schools, vocational education, and businesses and industry must be fostered.

Education has an important impact on economic development. First, it helps people acquire information, skills, and attitudes that enable them to understand economic changes and developments. It also improves individuals' efficiency and their ability to adopt new technologies. Second, investment in education is one of the most important sources of the human capital that makes invention and discovery possible. Third, the community's ability to

adopt advanced technologies is supported by a well-educated workforce. All of this highlights the role and importance of education in economically sustainable aspects.

2.4 Sustainable School Concept

The above confirms that education is considered a critical tool for sustainable development with its socio-cultural, environmental, and economic aspects. But there are four main levels of education depending on the age of people involved and the objectives and topics learned (see Figure 2.5). These four levels of learning can be divided into basic education (schools), university, organizational (private and public), and lifelong learning. The basic education level includes primary, higher, and vocational schools. The University level includes postgraduate and graduate courses. The level of the organization includes institutions and companies. Lifelong learning includes informal learning or self-learning through life experience.

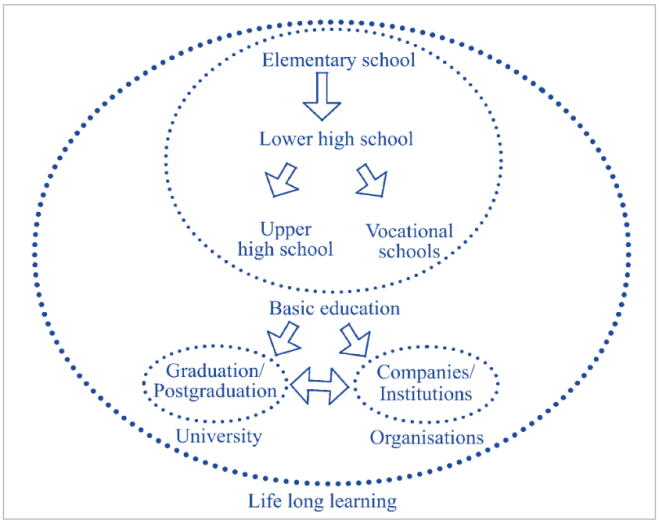

Figure 2.5. The education system has four learning levels (Source: (Martins et al., 2006)).

Our framework aims to cover the basic formal education system: elementary schools, lower and upper secondary schools, and vocational schools. It focuses on creating a culture of sustainability through continuous improvement of the sustainability of the school's complex management system. This work includes professional development for students, teachers, and administrators, improving access to quality learning resources, and policy development. The following subsections illustrate how these actions will help schools integrate sustainability into management and curriculum.

It is well known that the foundations of individual knowledge and attitudes toward the environment and society are formed in early childhood (Kahriman-Pamuk et al., 2019). For this reason, it is important to begin EfS in the early years. Children can play a dynamic role in changing both the present and the future, and the attitudes, values, knowledge, and experiences acquired in early childhood are essential for future experiences (Gueler Yıldız et al., 2021). Therefore, the United Nations has set EfS in early childhood as a goal in a report (2005-2014).

They should note that the school system is a complex system in society that interacts with each of the four sectors: the state (government), civil society, the community, and the business sector, as shown in Figure 2.6. These direct relationships may explain why it takes longer to address sustainability in schools than in other sectors of education (Grindheim et al., 2019).

- For the first relation with the state, public schools are officially part of the state (central and local government). They receive financial support and are subject to the authority of state ministries. Moreover, schools can create specified partnerships with the state to enhance educational and economic benefits to the community (Hatcher, 2014).
- There are many benefits from school and business partnerships (second relation), such as school sponsorship and business involvement in and for the community. Companies also act as professional mentors for students in future jobs and can be part of the curriculum.
- For the third partnership, the community is an integral part of the school system that can support, participate in, or even lead school actions, initiatives, and programs for the benefit of the future.
- And finally, Schools have partnerships with civil society, such as collaborations with NGOs and other local entities. Schools help students develop the right skills to become responsible citizens to develop and sustain a civil society.

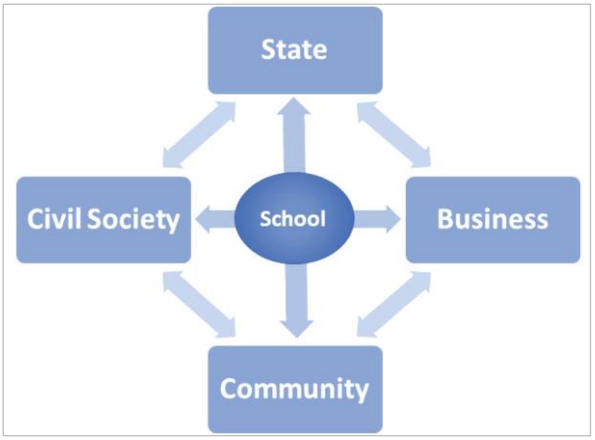

Figure 2.6. The scheme illustrates the School-Government-Business-Community-Civil Society Partnership (Source: (Alkaher & Gan, 2020)).

Thus, comprehensive measures are needed to respond to the needs and priorities of education for sustainability in schools. They should incorporate the whole-school approach to sustainability. This is because this holistic concept is given importance at all levels and in all parts of the school organization, as shown in Figure 2.7. It can help ensure that an educational institution's curricula, programs, practices, and policies contribute to building a more sustainable future. In the school-wide approach, sustainability is not only taught, but also lived.

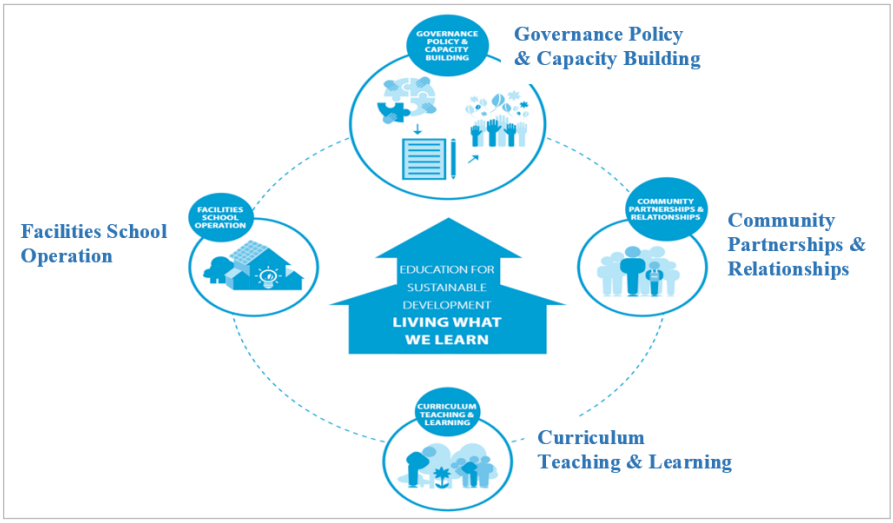

Figure 2.7. The whole-school approach to sustainability (Source: (UNESCO, 2014)).

2.4.1 Whole-School Approach for EfS (WSA)

The Whole-School Approach is a framework that helps schools embed educational principles for a sustainable future in consultation with all (school) stakeholders (Bosevska & Kriewaldt, 2019). It helps to embed sustainable development in all areas of the school organization. This means that sustainability becomes a natural attitude and way of life at school.

The whole-school approach typically addresses all members of the school (students, staff, families, and the broader community). It uses multiple components of policies and practices to promote a positive and physical school environment, teach social and emotional skills, and engage parents and support students with special needs (Mogren et al., 2019). Therefore, WSA is considered a complex approach that targets social and organizational change at multiple levels in the school community. This complexity contributes to a gap between theoretical research and implementation (Pearce et al., 2022).

The ESC has outlined the various educational processes of the school that influence learning. These are curriculum, pedagogy and didactics, professional development, building management, operations, and the school environment, as shown in Figure 2.8. These processes or areas are interconnected through the school's vision of education for sustainability (UNDP, 2015). This means that the next actions and sections should be based on these areas.

2.4.2 School Vision

Vision is at the core of the whole-school approach with the question, "Why and for what purpose do we learn?" This vision must achieve the two most important goals of the school. First, the vision revolves around the school's responsibility for children and their development as people, citizens, and professionals. Second, it is about the school's responsibility to the community and ecology around us. In addition, the ESC supports sustainable development by asking the important question, ‘How can and will our school

contribute to a sustainable world and future?' To develop a sustainable vision, school leadership must bring together a broad group of students, staff, and other stakeholders such as parents, businesses, and the community. This vision inspires and forms the foundation for EfS. Sustainability issues are admittedly complex and rapidly changing in our world. Therefore, the school's vision should be living and adapted as needed.

Figure 2.8. The educational processes in the whole-school approach for EfS (Source: (UNDP, 2015)).

2.4.3 Embedding Sustainability in Curriculum

Sustainability issues must be considered from an integrated and multidisciplinary perspective because they are complex and interrelated. Therefore, education for sustainability must be reflected in all curricula. The curriculum helps students acquire the knowledge, skills, and values they need to participate in solving future sustainability challenges. As a result, all curriculum materials should incorporate diverse disciplines, cultures, and perspectives, including the knowledge and worldviews of indigenous peoples.

However, transferring all this new knowledge into programs is challenging and requires a highly developed knowledge community to ensure its existence (Solís-Espallargas et al., 2019). It requires the intervention and participation of stakeholders related to the topic, such as the government, the school administration, and some ministries, such as the Ministry of Energy and Environment, the Ministry of Water, and the Ministry of Cultural Heritage and Arts, in consultation with territorial governments, to ensure that the topic of sustainability is formally addressed in school curricula.

2.4.4 Professional Development for Teachers

Teachers are a critical factor in EfS because of their ability to shape better educated future generations (UNDP, 2015). Teacher effectiveness is recognized as an important factor influencing student behavior and achievement (Bae & Kim, 2016). Teacher quality is based on factors such as teacher knowledge, professional behavior, pedagogical knowledge, teacher

certification, teacher recruitment, and teacher compensation (Kyndt et al., 2016). (Choi & Kang, 2019) emphasize that collaboration, reflection and feedback, 'in-school and out-of-school practice," and support from other teachers are critical factors that improve the sustainability of professional development.

Teacher collaboration, as an essential component of professional development, occurs when teachers share school practices and strategies, make decisions about pedagogical issues, and develop great ideas that promote sustainable learning for all members of the school. This requires collaboration between teachers and school leaders to create a conducive and effective environment for the development and promotion of professional development and the development of teacher resources. Without factors that promote the sustainability of professional development, professional development would not be able to implement sustainable change.

2.4.5 Pedagogy and Didactics

Pedagogy is about your attitude as a teacher, paying attention, being a role model, and building relationships. Didactics is the term we use to describe the method of teaching. What teaching methods are used and how can a learning environment be created in which students can explore what they think is important? How can this help students advocate for a sustainable world? These are important issues because a more intensive relationship between students and teachers both inside and outside the formal classroom can lead to academic success, good academic performance, higher educational aspirations, personal and intellectual development, student satisfaction, and increased motivation (Bovill, 2020).

Educational interaction between teachers and children consists of three main areas: emotional support, classroom organization, and instructional support (R. Huang et al., 2019). Therefore, ideally, teachers and students should jointly create learning platforms and approach learning interaction situations in a way that promotes students' learning of new knowledge and the teacher's ability to teach.

(Mogren et al., 2019) argues that the teacher plays the main role in creating learning environments and situations for students, supported or hindered by the qualities of the school in terms of other organizational dimensions, namely holistic, routine and structures, and professional knowledge building. When these three dimensions are coherent, they support practical pedagogical work, improve student learning outcomes, and improve the school. On the other hand, a school with opposing characteristics, poor knowledge formation and a strict schedule with a lack of holism, can lead to poor practical pedagogical work and poor outcomes.

2.4.6 Building Management and Operations

Coordination between the school's vision and the physical learning environment is important to achieve learning for sustainable development in life. The physical environment of school buildings and grounds is the public health and safety of students, staff, and visitors (Allison & Dickay, 2020). Users of the building, schoolyard, cafeteria, and classroom need to learn about the importance of thinking and acting sustainably. This is done by thinking about

sustainable energy, recycling, a healthy and sustainable cafeteria, workshops, and classrooms and schoolyards with lots of green space. This creates a school environment that breathes sustainability.

The importance of a healthy physical environment for schools is that it provides the best nutrition, clean water, air, necessary health care, and basic safety for all. In addition, a healthy school helps students learn through instruction and real-world examples. Therefore, the physical school environment (buildings and grounds) must be designed, maintained, and renovated to be healthy, safe, and risk-free to promote sustainable learning.

The school can demonstrate the value of the vision and sustainable principles it embraces through its policies and operations. The school should consider facilitating sustainable transportation, using green ICT, and renovating buildings in a sustainable manner. It should also use sustainable criteria when contracting in areas such as cleaning, purchasing, and energy (Moore et al., 2019). In addition, schools should also pay attention to the social aspects of sustainability, such as participation, inclusion, equity, and managing diversity.

2.4.7 School Environment

The school environment is an important factor influencing learning goals and feedback, opportunities for social skills development, and strategies to support student success. It can have a positive impact on the health of the learning environment or be a significant barrier to learning (Brandisauskiene et al., 2021). The school environment includes a combination of factors such as the physical environment, the learning environment, student readiness, student health, and social practices.

A sustainable school environment aims to develop strong and resilient individuals who can deal with complex challenges through social behaviors and skills that promote well-being and achieve sustainability goals. This can be done through a good school’s relationships with the broader community, including parents, authorities, communities, NGOs, residents, local entrepreneurs, media, and other schools (Ferreira et al., 2020). For example, the school's relationship with NGOs helps create educational opportunities, encourages support for various school projects, and reinforces the importance of expert visits to the school. On the other hand, the close relationship between school and society helps the school to address some related social problems.

In conclusion, we would like to emphasize that the concept of sustainable school is an integrated approach to the school as a whole system, where sustainability is integrated into all aspects of school life, not just the physical environment. A sustainable school creates positive outcomes for all involved in the educational process and impacts school community cohesion, relationships, and the well-being of its members. It also encourages student motivation and behavior to participate in the learning process and decision-making. School sustainability encompasses curriculum, ethics, relationships, capacity building, building cohesion, and managing operations. Moreover, sustainability is not a fixed fact, but a dynamic process that can be constantly changed, and the school community is an important factor that determines its direction and growth.

All of this proves the importance of sustainability education, especially at the basic level of education. The whole-school approach is an effective way to create a sustainable school environment. But the methods and tools to assess and evaluate sustainability with its three pillars in schools are not well developed (Kahriman-Pamuk et al., 2019). It is critical to know how to reliably measure progress in implementing sustainability practices in schools so that the impact of these efforts is meaningful. We will focus on this in the next chapters.

2.4.8 Role of School Stakeholders

School stakeholders primarily consist of students, teachers, and principals. Each stakeholder group has distinct environmental and socio-economic interests and concerns, as described following. Thus, these factors will reflect the diverse sustainability issues within schools, which carry varying degrees of importance.

Students Role

Students are critical as initiators, drivers, and contributors to sustainability processes. They will be most successful in this role if they are responsible, engaged, and positive. Therefore, social responsibility should be an integral part of the educational process from kindergarten through primary and secondary schools to universities. Developing a sense of responsibility in students helps them set clear goals, work hard, and find practical solutions to social, economic, and environmental challenges and perform better (Buğdayci, 2019).

Social responsibility provides an ethical and meaningful way to interact with the world and educate students about their surroundings and sustainability. One of the best ways to teach students social responsibility is to have them actively participate in their learning. Have students discuss what they learned in class and how they are using it to better themselves. Social responsibility can improve the social and environmental well-being of communities at both the school and state levels. It is integrated into all aspects of school life, including instruction, research, and public events and activities. It includes a variety of activities such as: i) community participation, ii) equity, diversity and inclusion, iii) sustainability, and iv) humanitarian activities.

Students can fulfill their social responsibility in different ways during their studies. The first step in being a socially responsible student is the art of preservation. For example, students should understand the need to separate garbage and conserve water and other non-renewable energy resources. Second, they should participate in volunteer activities. These activities can be inside the school, such as tutoring students with special needs, or outside the school, such as caring for the sick and interacting with the elderly. The most important step is following morals. Moral codes enable students to distinguish between right and wrong, i.e., to strengthen their social responsibility as citizens.

Students' level of social responsibility in school varies depending on several variables, as shown in Table 2.7. These variables include the student's gender, grade level and field of study, parents' education level, and volunteer activities and sports training. In general, the sense of social responsibility (SR) of female students is higher in relation to the variable "gender". As for the "variable "school level", elementary school students have a higher level

of responsibility than high school students. In addition, students in academic schools have higher levels of SR than students in vocational schools.

Table 2.7. The variables that the student's level of social responsibility depends on.

Variable	Observer	Explanation	Reference
Student Gender	The SR levels of the female students are higher than the male students.	Female children are more empathetic, sensitive, passive, flexible, and helpful to others and can establish intimate relationships compared to male children.	(Buğdayci, 2019)
Grade	The students in basic grade (ex.5th and 6th grade) have higher scores on SR, compared to secondary school (ex. 8th to 10th grade).	Secondary school students prefer to prepare for high school entrance exams, so they focus on only this point, which results in their lower SR behaviours.	(Filiz & Demirhan, 2019)
Study Field	Students in academic schools have higher levels of SR than students in vocational schools.	Being part of a field that promotes a commitment to social relations, caring for others, the public interest, and preserving the environment for future generations is associated with higher levels of SR in young people.	(Galvão et al., 2019)
Parental Level of Education	Students whose parents are more educated have higher SR scores than those whose parents are less educated.	Parents' education is positively associated with increasing the degree of personal autonomy, which in turn helps in improving SR for the student.	(Carbonero et al., 2017)
Volunteer Activities and Sports Training	The SR levels of the students, who were doing volunteer activities and sports, are higher than others.	Volunteer work and athletic training makes positive contributions to SR behaviours, and fosters relationships and a spirit of cooperation and participation.	(Galvão et al., 2019)

Teachers Role

The role of teachers in creating sustainable schools is critical. Teachers are responsible for shaping the minds of the next generation. They can instill in their students the values and knowledge necessary for a more sustainable future.

An important aspect of a sustainable school is the integration of environmentally friendly practices. This includes reducing energy and water consumption, promoting recycling and waste reduction, and incorporating outdoor lessons and field trips where students can learn about and interact with nature. Teachers can play an important role in implementing these practices in the classroom and school community by modeling sustainable behaviors, incorporating sustainability education into the curriculum, and engaging students in conservation learning projects. (Agirreazkuenaga, 2019) found that integrating sustainable

school practices is positively associated with students' environmental knowledge, attitudes, and behaviors. The study also highlights the importance of teacher education in promoting sustainability in schools.

In addition to promoting environmental sustainability, sustainable schools prioritize the well-being of the whole student (Sund & Gericke, 2020). This includes promoting social and emotional well-being, physical health, and safety. Teachers can promote student well-being by creating a positive classroom culture, incorporating mindfulness and yoga practices, and providing students with opportunities for physical activity and healthy eating. This underscores the importance of the health promoting schools (HPS) approach, which aims to empower students to take an active role in promoting their own health and the health of their school community and society.

To create sustainable schools, teachers must collaborate with other stakeholders, including administrators, parents, and community members. This collaboration can take many forms, such as developing a school sustainability plan, participating in community cleanups, or hosting a sustainable lifestyle fair. By teachers, administrators, parents, and community members working together, a culture of sustainability can be created that extends beyond the classroom and into the community.

In summary, the role of teachers in sustainable schools is critical. Teachers can instill in their students the values and knowledge necessary to create a more sustainable future by modeling sustainable behaviors, integrating sustainability education into the curriculum, promoting student well-being, fostering positive relationships, and promoting an inclusive learning environment. By collaborating with other stakeholders and empowering students to take an active role in promoting their health and the health of their school community and society, teachers can help create sustainable schools that positively impact both individuals and the environment.

Principals Role

School leaders take the lead in providing students with opportunities to develop the knowledge, skills, and attitudes they need to succeed in business and society and to protect the environment. School leadership is important not only to meet challenges, but more importantly, to achieve long-term goals for students' careers and lives. Today's society and local/global economy demand not only academic success, career preparation, or civic engagement from the younger generation, but a combination of all of these.

Consequently, school leaders are focused on developing a vision for their schools, creating learning communities, and ensuring quality curriculum, instruction, and assessment are implemented in the school building with consideration of the coming changes (Stronge & Xu, 2021). To achieve sustainability in schools, one must focus on the following key attributes:

- Building a school vision and its sustainability.
- Monitoring assistance and support.
- Curriculum coordination and supervision.

- Leading the learning community.
- Use of data to make educational decisions.

A high-quality school, education for sustainability, and students' well-being start with the principal. Effective principals are change agents and institutional entrepreneurs who initiate and drive meaningful innovation in their organizational and educational environments. (Liebowitz & Porter, 2019) found that there are always positive relationships between an increase in a principal's time or skill and student achievement, teacher well-being, instructional practices, and school organizational health.

2.5 Conclusion

This chapter has shown that the level and quality of education have an important direct or indirect impact on sustainable development (social, environmental and economic dimensions). They sharpen the minds of individuals and contribute to the improvement of social, economic, and environmental development. Therefore, the quality of education for students, lecturers (teachers) and the quality of infrastructures and classrooms have always been of paramount importance for education and school stakeholders. In addition, the quality of health facilities for studentsand staff, as well as the general environment of the institution, is important to school stakeholders. Education is the cornerstone of sustainable development and therefore requires special attention.

The literature review has shown that specific methods and tools for implementing sustainability in schools are still lacking. Therefore, we need to develop these methods and tools to help policy makers, administration and communities to effectively implement sustainability in the education system. This research contributes to this goal by developing these methods and tools and their application to improve school sustainability in Palestine.

Chapter 3 Research Methodology

3.1 Introduction

The previous chapter highlighted the important role of the education system in promoting societal progress towards sustainability. Therefore, this research aims to assess the sustainability of public buildings and school systems. This chapter outlines the methodological steps to develop a framework that promotes sustainable buildings and schools and facilitates the application and evaluation of the concept. This goal forms the core contribution of this thesis, with a focus on creating a comprehensive sustainability assessment framework and tool specifically designed for public buildings and schools.

This chapter first presents the background of the Palestinian construction sector and education system, highlighting the particular challenges related to sustainable public buildings and schools in the selected case study area. It also shows how these challenges can be addressed using the pressure-state response (PSR) model to create a model for comprehensive and systematic assessment of public building sustainability.

In addition, this chapter describes the materials and methods used throughout the research process. It introduces the Delphi survey technique as a key method for collecting expert opinions and validating assessment indicators. The SWARA (Stepwise Weight Assessment Ratio Analysis) and AHP (Analytic Hierarchy Process) analytical methods are also used to determine the weighting of assessment indicators. These approaches ensure a systematic and rigorous examination of sustainability practices.

3.2 Overview of Research Methodology

The proposed research methodology includes three stages, as shown in Figure 3.1.

I. The first phase is the literature review, which gathers information from two main sources: existing global sustainable rating systems and review scientific papers. This phase aims to review the advantages and limitations of these existing systems, as well as the classification attributes used to assess the sustainability of public buildings and schools specifically and to look for the contribution of recent research in this field as explained in the previous chapter.

II. The second phase focuses on developing a sustainability assessment model appropriate to the Palestinian context. In this chapter, we will introduce Palestine as a case study area. The construction sector in Palestine discusses the motives and difficulties facing sustainable construction, and the interrelationship between education and sustainability in Palestine. These issues are very important for the development of an appropriate assessment framework for buildings in Palestine, and Chapter Four explains this development of the model in detail.

III. The third stage is the application of the model. It is based on data collection using school field data and questionnaires. Then, data analysis is used to obtain a sustainability index and is used AHP and SWARA methos to calculate the indicators weights. The results and recommendations will be presented, expressing the

contribution of the research as well as the limitations of this study. Phases III will be discussed in this Chapter.

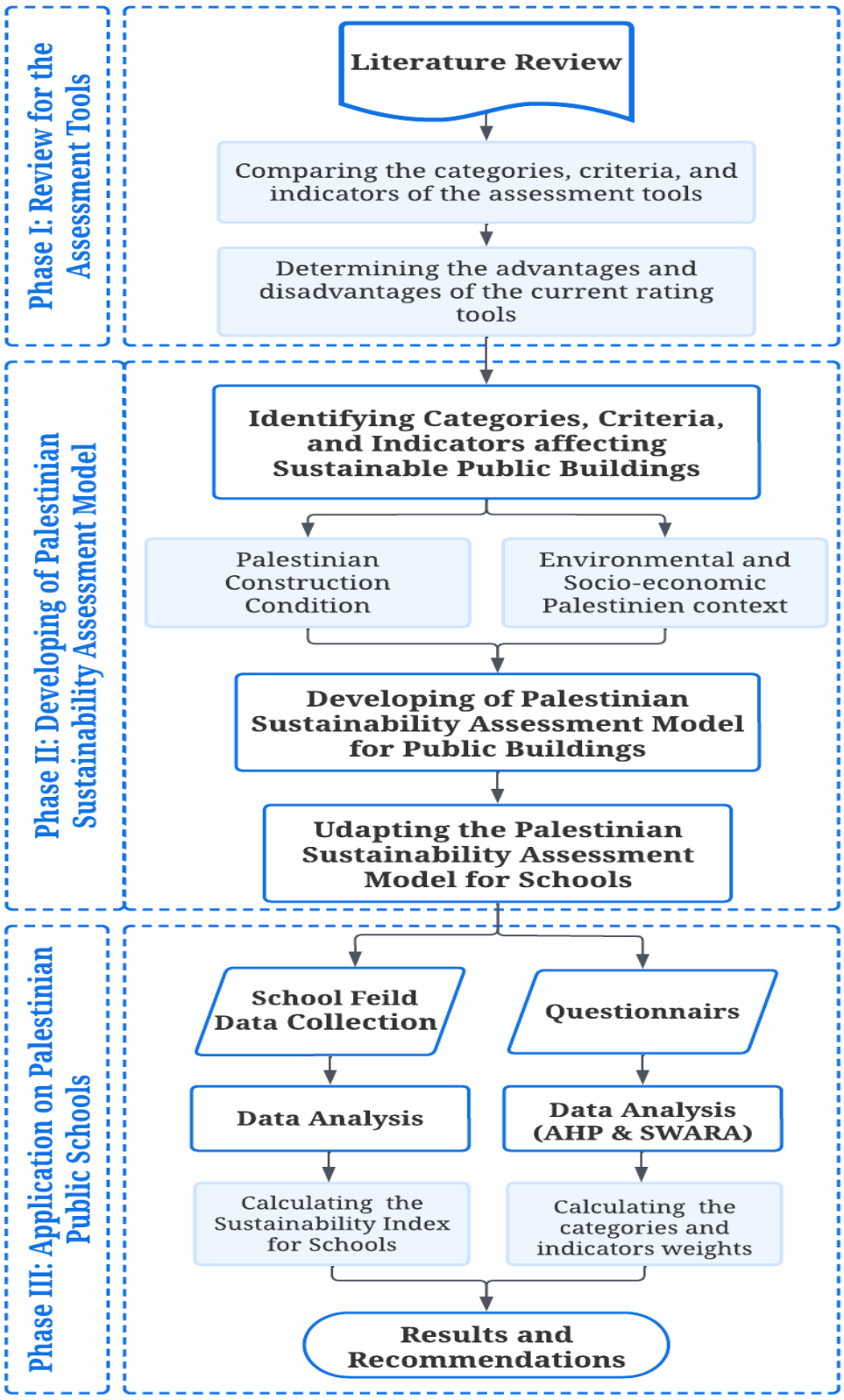

Figure 3.1. Research Methodology Flowchart for Palestinian Sustainable Model for Public Schools.

3.3 Study Area: Palestinian Case

Palestine is an interesting case study area for evaluating the sustainability of building practices. An important aspect that distinguishes Palestine is its status as a state under occupation. This political reality has far-reaching implications for the construction sector and sustainable development. The use of natural resources, including electricity, natural gas, water, and salt, is a major challenge. For example, the Palestinian Authority relies on importing 100% of its petroleum products from the Israeli market and approximately 87% of its electrical energy from the Israeli Electricity Company (Abu Hamed & Peric, 2020). The decisions of the Israeli authorities have also resulted in the confiscation of groundwater and the prevention of Palestinians from digging new wells. In addition, political conflicts have destroyed vital water infrastructure such as wells, irrigation systems, reservoirs, and pipelines. These adversities hinder sustainability in the construction sector and underscore the urgent need for innovative solutions.

Palestine's geographic diversity is another compelling aspect of its suitability as a case study area. The region is divided into the West Bank and the Gaza Strip, each with different environmental and climatic conditions. The West Bank, for example, has different terrains, including mountainous regions, fertile valleys, and arid areas. In contrast, the Gaza Strip spans a narrow coastal plain. These geographic differences contribute to the diversity of building practices and sustainability challenges in the different regions of Palestine. In addition, Palestine's high population density, which according to the Palestinian Central Bureau of Statistics is 794 people per square kilometer, adds to the complexity of sustainable building efforts. Meeting the needs of a growing population while ensuring environmentally friendly practices is a major concern. Balancing housing demand and infrastructure development with sustainable principles is essential to long-term environmental and social well-being.

By studying sustainability in the construction sector in Palestine, valuable lessons can be learned and applied in other regions facing similar challenges. It provides an opportunity to explore innovative approaches, technology adoption, policy frameworks, and community participation strategies that can promote sustainable development despite prevailing constraints. It also highlights the importance of collaboration between governmental and non-governmental organizations, local communities, and international partners to achieve sustainable building practices and a resilient urban environment. Overall, the examination of Palestine as a case study region provides a unique and informed perspective on the complexities and opportunities of integrating sustainability into the construction sector under political, geographic, and socioeconomic conditions. It emphasizes the importance of considering sustainability holistically, taking into account environmental factors as well as social and economic dimensions.

3.3.1 Construction Sector in Palestine

The construction sector in Palestine has a significant impact on the social, environmental, and economic aspects of the region. According to the Palestinian Central Bureau of Statistics, the construction sector registered a growth rate of 36% in 2010, and the number of employees

increased by 22% compared to 2009. It contributed about 13% to the gross domestic product of the Palestinian economy in 2014, making it the second largest contributor (Ardda N., Mateus R., 2018). This sector also plays an important role in job creation, employing about 11-15% of the Palestinian labor force. Thus, the construction sector in the West Bank is considered a major pillar of the national economy.

Historically, Palestine has been very diverse in the use of building materials, which played a crucial role in defying natural factors, climatic changes and the environment. Local materials such as stone, pottery, and concrete were used, which suited the climatic conditions of the region and provided an element of sustainability. In addition, traditional building methods improved energy efficiency. For example, the use of courtyards allowed for natural ventilation, lighting, energy conservation, and social benefits. However, at the beginning of the twentieth century, major changes in construction methods occurred in Palestine due to changes in the social and economic aspects of life and the introduction of new building materials. (Salameh, 2012) pointed out that the prevailing construction practices in Palestine did not consider the concept of sustainability. As a result, construction practices have become more complicated and operation and maintenance costs have escalated. People have started to use modern building materials such as glass and metal because of their affordability, esthetic advantages, and ease of implementation, ignoring basic problems such as heat loss or absorption. This has increased operational demands and the need for constant maintenance, and has resulted in significant waste generation. As a result, old buildings in Palestine are more in line with sustainability principles than modern buildings.

The Palestinian territories are divided into three distinct regions: A, B, and C. Areas A and B are classified as urban areas and are under the official control of the Palestinian Authority. However, the remaining 61% of the territory falls under Area C, where Israel has full control over security and civil affairs, including planning, building regulations, infrastructure development, and more. This arrangement is a major challenge, as it has led to arbitrary building practices and non-compliance with building codes. As a result, standards have been neglected and green spaces have been impoverished by rapid urbanization, leading to a weak focus on sustainability (Saeed, 2019). These factors have had a tangible impact on social life in the region. This is evident in the unfinished concrete buildings, destruction everywhere, and neglect and reduction of esthetic elements due to financial constraints. Villages, towns, and refugee camps have become separate residential areas serving different social classes, contributing to the fragmentation of society (Sabboubeh et al., 2019).

As a result, the development of new and strict rules and regulations, such as the Energy Efficient Building Code 2004, has become inevitable. Many institutions have recognized the importance of achieving environmental, social and economic goals in the construction and housing sector, including the Cooperative Housing Foundation (CHF), initiatives to revitalize land cultivation in the Jordan Valley - Palestine, and the Palestinian Higher Housing Council - Green Buildings Guidelines 2013.

Energy Efficient Building Code 2004

The Ministry of Local Government published the Energy Efficient Building Code in 2004 as a modern building regulation. Its main objective is to improve Palestinian building practices by focusing on the thermal design of the building's exterior elements and determining the required thickness and insulation properties. The code aims to reduce energy waste and protect the environment by reducing greenhouse gas emissions and ensuring thermal comfort for building occupants (Palestinian Energy Code, 2004).

For example, the code sets maximum values for thermal transmittance of walls and floors, as shown in Figure 3.2. These values vary depending on the specific heating and air conditioning requirements of each space. The code emphasizes the importance of insulating walls and floors because they greatly affect heat transfer and water condensation. In addition, the code provides guidelines for window characteristics (single, double, or triple glazing), allowable infiltration rates to maintain user comfort, and preferred window material (wood or aluminum), among other considerations. It also provides engineers with the necessary equations and parameters to accurately calculate these parameters.

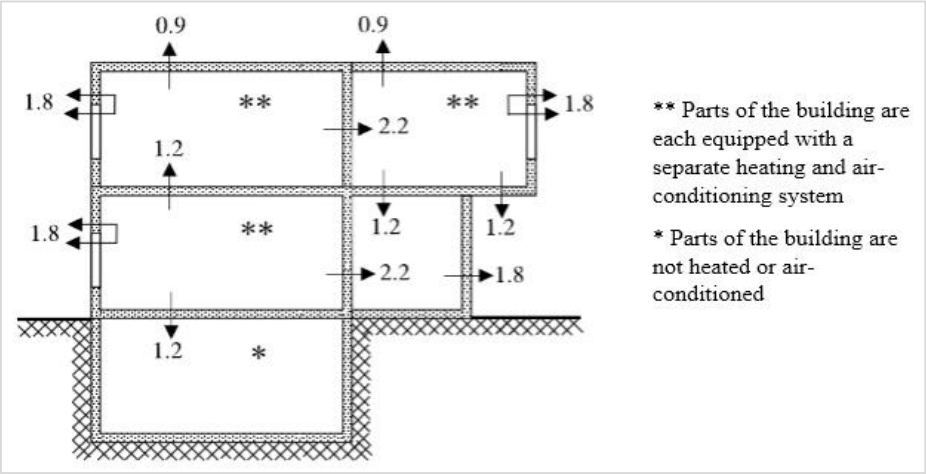

Figure 3.2. The required thermal transmittance ($W/m^2.K$) for walls and floors in the building. Source: (Palestinian Energy Code, 2004)

Green Buildings Guidelines 2013

The Palestinian Higher Council for Green Buildings was established in 2010 at the initiative of the Engineers Association - Palestine. This institution is responsible for setting regulations and laws and regulating engineering activities. The establishment of the Council involved cooperation with governmental and non-governmental organizations and individuals directly or indirectly involved in engineering activities. In 2013, the Higher Council for Green Buildings took an important step by establishing green building guidelines for Palestinian buildings and facilities and aligning them with international standards. The goal was to address societal challenges such as limited water resources, energy scarcity, and high building operating costs. Adopting the global green building concept while taking into account the unique climatic, geographic and topographical conditions of the region is crucial from a

sustainability perspective to ensure a happy and secure future for future generations (Palestine Higher Green Building Council, 2013).

The main goal of green buildings is to meet people's expectations and needs without harming the environment. This is achieved by focusing on three core principles: energy efficiency, utilizing local environmental, geographic and climatic conditions, and promoting sustainability. Therefore, the rating of a building as a green building depends on the building's ability to achieve the maximum score of 200 points in six parts:

1. Site sustainability (15% of the total points).
2. Indoor environment quality (15% of the total points).
3. Energy use efficiency (30% of the total points).
4. Water use efficiency (25% of the total points).
5. Materials and recourses (10% of the total points).
6. Innovative new technologies and integrated building design (5% of the total points).

After that, green building projects began to appear in Palestine. Notable examples include the Palestinian Museum in 2014, the new A. M. Qattan Foundation building (multipurpose cultural building), the Aqqaba Green School (which was recognized as the first green school in Palestine in 2016) in 2016, and the Shtayya green residential building.

When examining these rules and guidelines, it is clear that they place great emphasis on environmental aspects and disregard the economic and social dimensions. Moreover, they are not intended for a specific type of building, but are used for residential and commercial buildings, hospitals, universities, etc., which is not correct and sufficient. Therefore, there is an urgent need to enact laws in Palestine that cover all three pillars equally and ensure a comprehensive approach to sustainability.

3.3.2 Challenges of Implementing the Sustainable Buildings in Palestine

The sustainability movement in Palestinian society faces many obstacles and challenges, including:

1. Limited financial support: The main challenge lies in the limited financial resources available for sustainable building projects. The high initial costs associated with sustainable building practices are currently discouraging Palestinians from adopting these types of construction.
2. Industry awareness and lack of resources: Although industry leaders demonstrate a reasonable level of awareness and understanding of sustainable building strategies (Mouzaneh et al., 2022), this knowledge is not effectively implemented into design and construction practices. The lack of available building materials, technology, and management systems, due to Israeli restrictions, contribute to the weakness of the sustainable market in Palestine.

3. Absence of laws and regulation framework: Without a government regulatory framework, there is no compulsion for citizens to meet sustainable building requirements.
4. Lack of qualified human resources: There is a dearth of qualified professionals skilled in designing sustainable buildings, which hinders the implementation of sustainability.
5. Population density and climate changes: High population density limits the possibility and ease of creating a sustainable environment in cities. In addition, Palestine consists of seven distinct climatic zones (five in the West Bank and two in Gaza), which poses a challenge when designing sustainable buildings, because each climate region requires customized designs.

By addressing these obstacles, it is possible to overcome the challenges and promote a more robust adoption of sustainable building practices in Palestine.

3.3.3 Palestinian Education Sector

Education is a source of hope and change for the Palestinian community. After the 1948 catastrophe, students and teachers played an important role in rebuilding Palestinian society. Palestinian schools, universities, and non-formal institutions have helped preserve Palestinian national life and provide the skills necessary for personal and community self-determination. In recent decades, however, Palestinian education has had to contend with the repressive and often violent conditions of the occupation. Therefore, we need to transform education into sustainable education to combat these problems and difficulties.

The Ministry of Education and Higher Education (MOEHE) is responsible for managing, organizing, funding and developing the education sectors (directly managing or through supervision). These sectors are: Pre-school education, school education (primary and secondary), technical and vocational education, non-formal education, and higher education, as shown in Figure 3.3. The Palestinian National Authority administers and funds most primary and secondary schools. It oversees 73.3% of schools: 79.3% in the West Bank and 54.9% in the Gaza Strip. In addition, the United Nations Relief and Works Agency for Palestine Refugees (UNRWA) operates schools for Palestinian refugees. UNRWA manages 12.11% of Palestinian schools. In third place are private schools managed and funded by various foundations, charities, individuals, and corporations. They may be for-profit or not-for-profit.

A unified curriculum has been introduced in both the West Bank and Gaza after a long period of using curricula from other countries (Jordan and Egypt). The implementation phase of the national curriculum in all subjects began in 2000, and by the beginning of the 2006-2007 school year, all students in all grades were using Palestinian national textbooks.

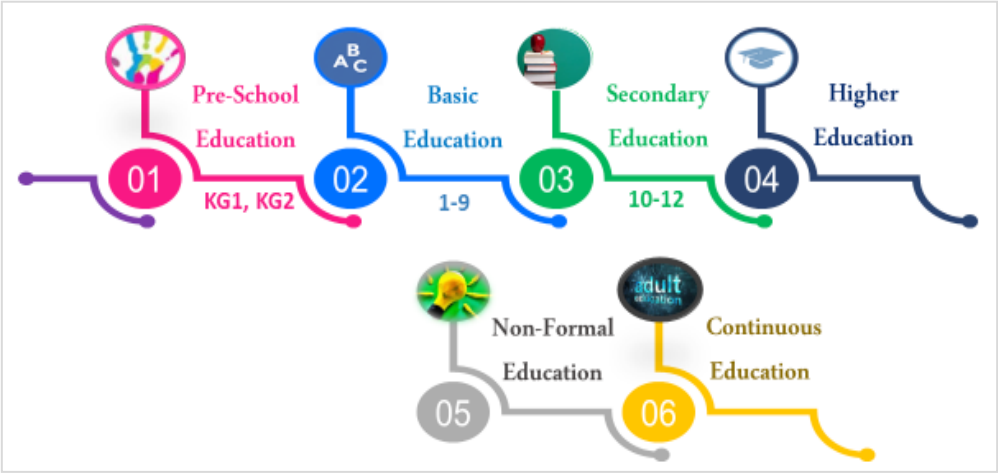

Figure 3.3. The structure of Palestinian education system (Source: (Ministry of Education, 2021)).

Reforming education and improving its quality has become the focus of the Palestinian government and society in response to complaints from students, teachers, parents, educational institutions, and businesspeople (Ministry of Education, 2017). These complaints are related to the quality of education and poor educational outcomes (i.e., the level of education and knowledge that students acquire). Some complaints related to school facilities, teaching methods, student behavior, assessment methods, and the appropriateness of educational content to labor market needs and social development. These problems placed a collective burden on the political, educational and social levels of Palestinian society. Therefore, education stakeholders need to adapt the education system to produce a sustainable generation with skills, knowledge and ethics. A flexible generation capable of dealing with life's challenges, contributing to research and scientific invention, and solving problems.

3.3.4 Palestinian Education and Sustainability Nexus

The Palestinian Education Framework has been updated to link the vision of Palestinian schools to the SDG 2030 targets, as shown in Figure 3.4. The vision of Palestinian education is as follows: “a Palestinian society that has values, culture and technology to produce knowledge and use it for its liberation and development.” It can be considered as a starting point for restructuring educational strategies and activities.

The first goal of the Palestinian education sector is to ensure safe, inclusive and equitable access to education and a learning environment free of violence for students and teachers. It aims to make the necessary changes in education policies and focus efforts on the disadvantaged groups in society, especially people with disabilities, to ensure that no one is deprived of the right to education. This goal has two dimensions: The first is to improve enrollment in all levels of education and to find a balance between them. The second goal is to maintain good enrollment and educational participation rates.

The second goal is to ensure the quality of education, improve educational outcomes, strengthen inputs and processes, evaluate outcomes, and define mechanisms to measure progress. This goal can be achieved by ensuring that teachers and educators have good

working conditions and adequate professional training. This helps improve the skills, knowledge, creativity, and values that help citizens live with dignity. Education for sustainable development addresses local and international challenges.

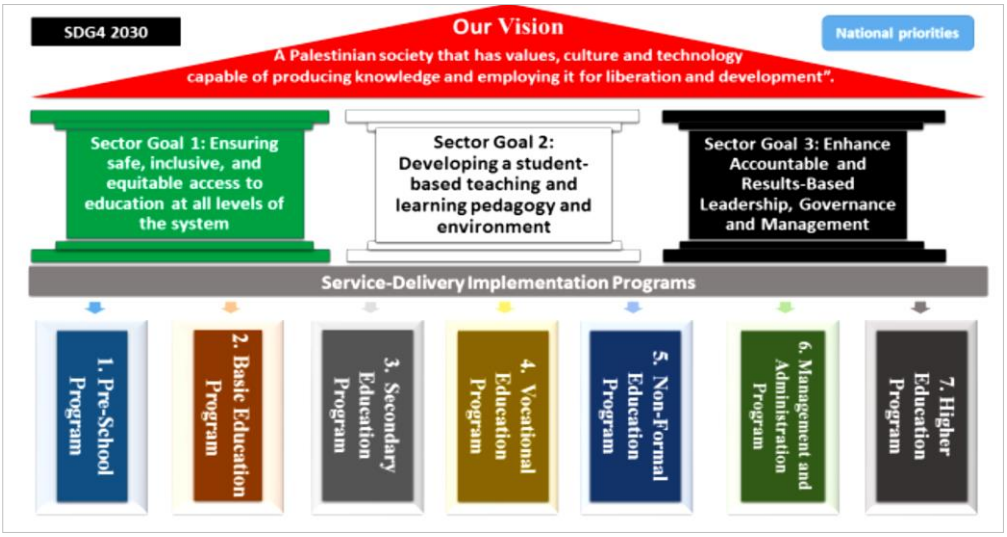

Figure 3.4. Logical Framework linking vision, goals, and service programs in the Palestinian education system (Source: (Ministry of Education, 2017)).

Achieving this sustainable vision and objectives require the following steps (Ministry of Education, 2021):

- Reducing bureaucratic structures in school systems that hinder the achievement and development of goals.
- Encouraging students to read, research, and self-learning through curriculum development.
- Students are the most important part of the educational process and the most important pillar of a sustainable society.
- School leaders and education stakeholders should focus on the prevailing social norms that include beliefs, development, and knowledge that guide the system toward values and vision.
- Learning operational processes shall be subject to continuous development, improvement, and monitoring.

We note a strong correlation between the goals of the Palestinian educational system and the goals of sustainability and the importance of education in achieving them. However, these goals are still initiatives that the ministry seeks to achieve. It also seeks to develop financial management to optimize available resources.

3.3.5 School Built Environment (School building)

According to the Palestinian Central Bureau of Statistics, there were 2,005 public school buildings in 2011-2012, which will increase to 2,307 by 2021-2022 (15% increase). In 2021-2022, the number of public schools in the West Bank is 1,878, with 602,389 students and 39,406 teachers. The gender distribution of students is 291,100 male and 311,289 female.

The school building in Palestine is usually a stone building, and there is a large asphalt area for the play area, resulting in a large heat island. Therefore, materials with a low solar reflectance index (SRI) must be used to reduce the heat effect. Schools are considering this, but unfortunately not seriously on site. In addition, electricity prices in Palestine are the highest in the MENA region and account for a large portion of disposable income. The Buildings Department at the Ministry of Education clarified that the annual electricity bill for schools is about 20 million shekels ($5.65 million).

According to the Environmental Quality Authority, government institutions, schools, and universities consume large amounts of paper, which is an economic and environmental burden. Paper waste, for example, accounts for about 10% of total waste. In the West Bank, about 262.8 tons of paper waste is generated every day, while in the Gaza Strip it is about 144 tons (Ministry of Local Administration). Therefore, many initiatives have emerged to dispose of this waste, whether through municipalities or individual initiatives, but they are very few and they represent only a small part of the total paper and cardboard waste.

The Ministry of Education is taking clear and serious steps to make new schools environmentally friendly and sustainable. The General Administration for Buildings is applying the Palestine Green Building Guidelines to schools, achieving the silver level with the following points. However, these standards and points are limited to new school buildings. There remains the question of renovating existing buildings. Therefore, this study addresses the improvement of these buildings to make them sustainable. (Source: General Administration for School Buildings - Palestine, 2020).

1. The green space has 30% area from the total area. And use local trees like olive, pine and cypress which don’t need a lot of irrigation.
2. The school must be close to the public transportation.
3. Harvest rainwater from the school's yards, playgrounds, and roofs, and storing it in a water tank with a minimum capacity of 80 cubic meters. The collected rainwater is then reused for toilet flushing and irrigation purposes.
4. Insulated all external element in the school against heat and humidity, according to green guideline book.
5. Ensue high indoor quality (ventilation, daylighting, noise, and using comfort colours for finishing).
6. Public Safety (seismic design, fire safety design, exist emergency, etc.).
7. Renewable energy by using solar collector and solar panel. That is with cooperation with the Ministry of Energy that provides facilities to use.
8. Rehabilitation of the school for students with motor and visual disabilities in terms of movement path, colours, and others

3.3.6 Challenges of implementing the Sustainable Schools in Palestine

Although the Palestinian Authority recognizes the value and importance of sustainability in education, there are several significant challenges that hinder the incorporation of sustainability practices into schools, include:

1. Insufficient School Infrastructure: Lack of financial support for school construction contributes to overcrowded classrooms in many Palestinian areas. The urgent need to build new schools remains unmet due to limited resources.
2. Labor market challenges: Many graduates in certain fields face limited job opportunities, leading to high unemployment rates in the Palestinian market.
3. Low demand for vocational education: which affects the availability of training opportunities in specialized fields.
4. Education issues in Jerusalem: There are challenges in Jerusalem related to Israeli control over curriculum and schools, which affects the quality of education provided.
5. Limited physical activities and entertainment: Inadequate opportunities for physical activities and lack of recreational options for students in schools may lead to potential health and psychological problems later in life.
6. Decreased student motivation: Some students experience a decrease in motivation to learn, which may affect their educational outcomes.
7. Concerns about teachers' salaries: Low salaries can affect the education sector's morale and retention.
8. Lack of Textbooks and Supplies: The lack of textbooks and basic educational supplies is a major obstacle to students' educational experiences.
9. School dropout rates: There is an albeit small percentage of students who drop out of school, especially after the tenth grade, mainly due to poverty and its associated hardships.

While these challenges highlight the multi-layered problems and gaps in the Palestinian education system, the proposed sustainability framework can bring about positive change and progress. This framework addresses these gaps by integrating sustainable practices into the education system and promoting a culture of environmental awareness and responsibility among students, teachers, and the broader community. By incorporating sustainability principles into the curriculum, improving the school environment, and promoting inclusive and accessible learning spaces, the proposed framework aims to create an inclusive and sustainable atmosphere in the Palestinian education system.

3.3.7 Pressure-State-Response (PSR) Model

Having gained a comprehensive understanding of the Palestinian context, and in particular the conditions in Palestinian schools, it is critical to create a framework that promotes sustainability in public buildings and educational institutions throughout Palestine. To achieve this, it is beneficial to use a comprehensive and well-defined framework such as the PSR model, which is widely used in sustainability initiatives. It allows for a better understanding of the actions and activities that impact the state of a system and provides educational institutions and stakeholders with appropriate responses to these issues. The rationale for the PSR model is to answer the questions “What happened?”, “Why did it happen?”, and “How should it be done?”. The PSR framework builds the index with the logic of “pressure effects, state change, and problem solving” (F. Wang et al., 2021).

Pressure indicators can be observed through biological changes and trends in nature and socioeconomic activities and provide information on the question "What happened?". While status indicators are used to measure changes resulting from human activities and their impacts on society and the environment, and shed light on the question, “Why did this happen?” To cope with pressures and change the status of the system, governments and societal groups take adaptation measures, which are response indicators. These measures provide answers to the questions "How do we do this?" and "What should be done?". Figure 3.5 illustrates the interdependence of the ‘pressure-state-response’ cycle and highlights the close relationship between these components. In this work, a framework was developed to assess the sustainability of public buildings and school systems using the ‘Stress-State-Response’ model as a guiding principle.

The proposed PSR model serves the following purposes: i) to describe and represent the environmental, economic and social sustainability status of existing public schools at any point in time or over any period of time and in any location; ii) to assess the changes required for a sustainable transition; iii) to review the relationships between all stakeholders. Chapter 4 details how this methodology is applied to school buildings in Palestine and presents the final models for their sustainability assessment.

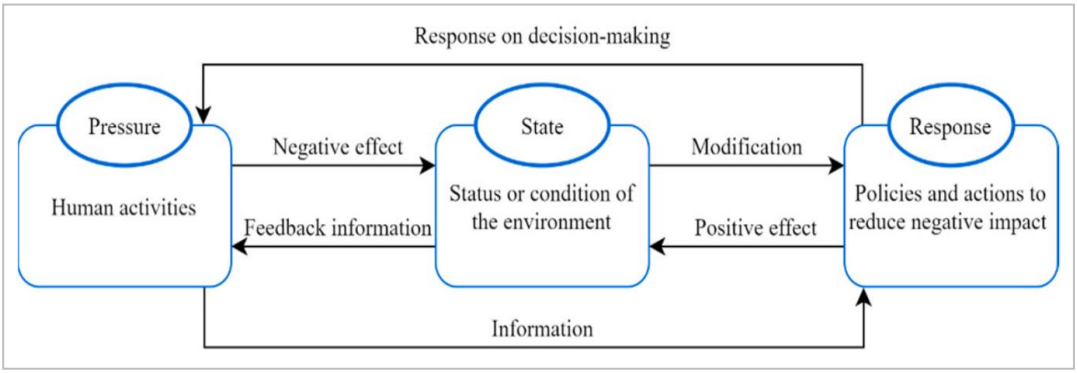

Figure 3.5. The pressure-state-response relationships in the PSR model (Source:(Lu et al., 2022)).

3.4 Phase III: Application - Palestinian Case Study

The third phase of the methodology is the application of the model. It is based on data collection using questionnaires and school data fields. Three questionnaires are used for data collection. The first one is aimed at experts to determine the meaning of each evaluation indicator and its applicability to the local context of Palestine. The second is aimed at school principals to obtain physical and social information about the schools. The third is intended for students to assess the indoor quality of the schools. In the following sections, these steps are described in detail. The data are then analyzed to determine a sustainability index and indicator weights using SWARA and AHP methods.

3.4.1 Data Collection - Experts’ Questionnaire

- The expert questionnaire is used to determine the importance of each assessment indicator and its applicability to the local context of Palestine through the opinion of

experts. The Delphi survey technique was used, which is a standardized and interactive research approach designed to collect the perceptions and judgments of a group of experts on a particular topic (Akhanova et al., 2019). It facilitates the identification of areas of agreement and disagreement, and helps researchers understand the agreeing and disagreeing viewpoints within the expert group. In this study, the Delphi process includes several stages, as shown in Figure 3.6: Questionnaire design, expert selection, data analysis and development, second round of expert opinions, weighting analysis, and compilation of results. As a result, two models of evaluation categories and indicators were created: one for public buildings and another for the school system.

- The first model of evaluation indicators was developed by reviewing established evaluation tools, as presented in Chapter 4. In order to validate these indicators, a questionnaire was sent to experts, academics, professionals, decision makers and engineers in Palestine to obtain their opinions. The aim was to ensure the relevance and applicability of each indicator to the local context. The opinions of the respondents were also used to calculate the weighting of each indicator. The results were analyzed and led to improvements in the original list by adding, replacing or deleting certain evaluation criteria.

- Similarly, the second school indicator evaluation model was derived primarily from the expanded public building evaluation model in the first questionnaire. It also included elements from recognized assessment tools specific to schools. Once again, a questionnaire was completed to solicit opinions from experts, education decision makers, and engineers in Palestine to determine the weighting of each indicator.

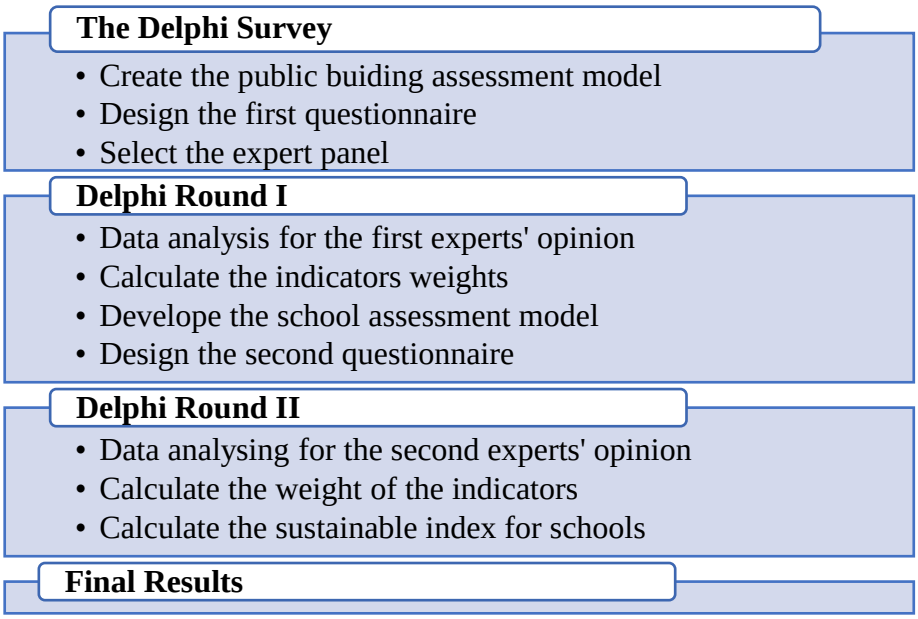

Figure 3.6. Delphi survey process flowchart.

These quantitative questionnaires consist of closed questions presented in the form of rating scales. The questionnaire is divided into two parts. The first part focuses on collecting personal information from the respondents, including their background and experience with sustainable projects, etc. The second part focuses on the list of sustainability indicators and asks respondents to rate the importance of each indicator on a five-point scale: 1 = completely unimportant, 2 = unimportant, 3 = neutral, 4 = important, 5 = very important. In addition, respondents have the opportunity to indicate additional evaluation points that they consider relevant, important or missing. These questionnaires are presented in Table 3.1, 3.2, 3.3, and 3.4, respectively, in Appendix 3.

3.4.2 Data Collection - School Field Data

This subsection represents the process used in this research, including schools' election, the questionnaire, and data collection.

The Selection Process

Schools from the Tulkarm and Nablus governorates in the West Bank of Palestine were included in the selection. This selection is due to the possibility of obtaining information and data from the Directorate of Education and the municipalities and schools. Tulkarm governorate is located in the northwestern part of the West Bank and borders the Mediterranean Sea to the west. Its area is approximately 246.5 square kilometers (Palestinian Central Bureau of Statistics). Nablus Governorate is located in the northern part of the West Bank and covers an area of approximately 598.5 square kilometers (Palestinian Central Bureau of Statistics). The region is characterized by rugged mountains, including Mount Gerizim and Mount Ebal, deep valleys and fertile plains. The city of Nablus is known for its historical and architectural heritage, including the well-preserved Old City with its traditional markets, narrow streets and historic buildings. By including schools from Tulkarm and Nablus, we were able to cover both social and geographic diversity.

The number of public schools in these two governorates is 409, and for this assessment we need a representative sample of 54 public schools, ensuring a confidence level of 90% and a marginal error of 10%. In Tulkarm there are 141 schools with 43,115 students and 2,193 teachers, while in Nablus there are 268 schools with 84,288 students and 4,128 teachers. Table 3.1 summarizes the data on schools in Tulkarm and Nablus.

Table 3.1. The distribution of public schools in Tulkarm and Nablus governorates (Source: Palestinian Central Bureau of Statistics).

	Tulkarm	Nablus
Number of Public Schools	141	268
Number of Primary Schools	77	140
Number of Secondary Schools	64	128
Number of Teachers	2,193	4,128

Number of Students	43,115		84,288	
Number of Students in Primary School	Girls	Boys	Girls	Boys
	16,421	16,619	31,969	31,408
	Total 33,040		Total 63,377	
Number of Students in Secondary School	Girls	Boys	Girls	Boys
	5,533	4,542	11,871	9,040
	Total 10,075		Total 20,911	

School Questionnaire Administration

The questionnaire was used to collect data on school sustainability. It includes four sections of closed questions for the academic year 2021-2022. The questionnaire was developed as an online survey using KoboToolbox software. The educational platforms of the directorates served as distribution channels so that the questionnaire could reach all schools. Face-to-face interviews were conducted to ensure a good understanding of the questions.

The first section focuses on general information about the school, including name, gender, grade level, location, number of students, staff, year established, and funder for the institution (government, donor countries, or individual donations). Table 3.5 in Appendix 3 provides details on the questions in this section.

The second section addresses the environmental and physical aspects of the schools, including (i) energy-related issues, such as the presence of photovoltaic panels, shading devices, and insulating materials, and (ii) water and sanitation issues, such as the availability of water catchment tanks and the efficiency of sanitation facilities. The section also considers (iii) site development, such as waste separation, the presence of green space, and the heat island effect. Table 3.6. in Annex 3 provides details on the questions in this section.

The third section focuses on the social aspect, including teaching quality, student engagement, dropout rates, and accessibility. It aims to provide insights into the various social dimensions of schools. Table 3.7 in Appendix 3 provides details on the questions in this section. The final section addresses economic considerations. It includes questions about the number of new employees, annual maintenance, and profit-making activities of the school. Table 3.8 in Appendix 3 provides details on the questions in this section.

To ensure the reliability and validity of the questionnaire, it was tested with a small group of participants to identify and correct any problems or ambiguities. During this process, the questionnaire was discussed with the school principal and the school inspector of the Education Directorate. This helped to discover the weaknesses and shortcomings of the questionnaire. On the other hand, it was explained how to formulate the questions clearly and how to make it easy for the managers to answer them accurately. This helped to improve the clarity and effectiveness of the questionnaire and to provide reliable and valid data that accurately reflect the sustainability practices of the selected schools.

Target Respondents

Appropriate targets are identified based on their participation and knowledge of sustainability practices in schools. In our case, the target is the Directorate of Education in Tulkarm and Nablus. This in turn forwards the questionnaire to the school administrators. This is because school administrators have a comprehensive understanding of the school's operations and policies. They are responsible for providing general information about the school, socioeconomic issues, and environmental characteristics.

In addition, municipalities and North Electricity Company are also included as key respondents in the data collection process. The reason for this is that the public schools in the selected regions rely on these entities for their electricity and water supply. In Nablus, the North Electricity Distribution Company is responsible for providing electricity to the public schools. On the other hand, the Nablus Municipality is responsible for supplying water to the schools. In Tulkarm, both electricity and water supply to the public schools are managed by the Municipality. Therefore, Nablus Municipality, Tulkarm Municipality and North Electricity Distribution Company were contacted to know the monthly electricity and water consumption of the schools. Their cooperation and provision of this data is crucial for evaluating sustainability practices related to energy and water consumption in the schools.

3.4.3 Data Collection - Indoor Quality Data

Students participated in the indoor environment quality assessment because they spend a large portion of their time in school buildings, which directly affects their well-being and ability to learn. By soliciting their views, we gain valuable insight into the user experience and can identify areas for improvement. Factors such as air quality, temperature, lighting, acoustics, and ergonomics can have a major impact on student health, concentration, and overall well-being, making it necessary to assess these aspects through student surveys.

Involving students in evaluating indoor space quality fosters a sense of ownership over their learning environment. By actively participating in the sustainability assessment, students are involved in creating positive change and advocating for improvement. In addition, students may notice problems or concerns that adults ignore and provide valuable information about issues such as inadequate ventilation or uncomfortable seating. By engaging students, we capture their unique perspective and enable them to contribute to a healthier and more appropriate learning environment.

Student questionnaires provide baseline data on indoor space quality that allows us to track changes and measure the effectiveness of sustainability initiatives over time. These assessments help create standards and set goals for improving indoor space quality. By engaging students, we create a collaborative and holistic approach to sustainability that improves their well-being, academic performance, and holistic learning experiences.

Therefore, the third questionnaire is conducted by students to assess the quality of indoor air in Palestinian schools. The students' questionnaire includes 14 questions that focus on the most important aspects of indoor comfort, including thermal conditions, acoustic quality, lighting, air quality, and the suitability of school furniture (see Table 3.9 in Appendix 3).

3.4.4 Date Analysis

Various methods are used to evaluate sustainability. (Li et al., 2020) summarized the main methods of sustainability assessment, namely Delphi method, Gray theory, MIVES, AHP method, fuzzy Delphi method, neural network BP, logical framework approach, TOPSIS method, extended matter element theory and SWARA method. All of these methods have good and great benefits for the evaluation process. In addition, each of these methods also has some disadvantages, as you can see in Table 3.2.

Table 3.2. The comparison among assessment methods for sustainability.

Method	Reference	Case application	Strength	Weakness
AHP method	(Kwatra et al., 2021)	The study was carried out to set sustainability in a regional context involving key stakeholders in prioritizing the various sustainable criteria and indicators in India.	1. It can solve problems involving several criteria and sub-criteria. 2. Its sensitivity and capability to represent differences between alternatives are important	1. It requires a lot of workload and time because it depends on experts' opinions. 2. It sometimes needs complex technology and knowledge.
MIVES method	(Josa et al., 2020)	The study was carried out to assess the sustainability of sport hall's roof in Spain.	1. It based on multi attribute utility theory. 2. It can use either qualitative or quantitative indicators. 3. It suitable for reporting results to non-experts.	Its structure based on different levels. Each one contains the different parameters to be studied and depends on the studied case. That requires a high and sensitive workload.
Fuzzy Delphi method	(J. C. Wang et al., 2019)	The study was carried out to evaluate the sustainability of elementary school in Taiwan.	It used to integrate the opinions of experts and scholars to achieve the goals. That improves user satisfaction and expectations.	It requires a lot of time and workload, and weights of indicators of different indicators are difficult to determine accurately.
Matter-element extension method	(M. Li et al., 2020)	The study was carried out to evaluate the degree of success of green and sustainability building projects in China.	1. It illustrates the relationship between the quality and quantity of the comprehensive assessment. 2. It can solve the multi-factor evaluation problem.	It is a little complicated because it is based on mathematical model methodology.

SWARA method	(Keršulienė et al., 2010)	The study proposed to solve the problem: a rational dispute resolution. It used in MCDM problems.	3. It is considered one of the simplest methods. 4. The expert has a significant role in the assessments and the calculation of weights.	It involves many of parties with different beliefs, values, and goals.
TOPSIS method	(Pinzon Amorocho & Hartmann, 2022)	The study presented a more complete Multi-criteria decision-making (MCDM) framework to support the decision-making process in building renovation in Europe.	1. It is the best MCDM methods of the ability to find the best alternative promptly. 2. It is an attractive way because the limited subjective input is needed from the decision- maker. 3. It can be applied in ranking machine learning models on basis of various factors	It is a little complicated because it is based on mathematical model methodology.

SWARA Method

The SWARA (Stepwise Weight Assessment Ratio Analysis) method is a systematic approach that helps evaluate alternatives based on multiple criteria and determine their relative importance. It differs from other decision-making methods in that it incorporates both subjective and objective aspects of decision making. This method, previously used by (Zolfani & Chatterjee, 2019), allows experts to use their knowledge and experience to evaluate the importance of each indicator.

The SWARA method offers many advantages in decision making. One of the main advantages is its simplicity and ease of understanding. The SWARA method avoids complex mathematical calculations, making it accessible to decision makers with different levels of experience. In addition, the SWARA method recognizes the importance of subjective and objective factors in decision making. By integrating qualitative and quantitative aspects, decision makers can make a more comprehensive assessment of alternatives, taking into account different dimensions and preferences. Finally, the method enables sensitivity analysis, which allows decision makers to examine the impact of changes in the weighting of criteria on final evaluations. This feature provides insight into the robustness of the decision and allows decision makers to understand the critical factors that affect the outcome.

However, the SWARA method is not without its weaknesses. One notable weakness is the accuracy of the results, which is highly dependent on the decision maker's expertise and consistency in evaluating the alternatives against the criteria. Another limitation is the potential problem of scalability when many alternatives or criteria are involved. The process can be very time-consuming and difficult to manage. Despite these weaknesses, the SWARA

method remains a useful tool for decision makers seeking a simplified and comprehensive approach to evaluating alternatives and making informed decisions based on multiple criteria.

The calculation process in SWARA includes the following steps (Keršulienė et al., 2010):

Step 1. The criteria are sorted in descending order of expected importance.

Step 2. Starting with the second criterion, the respondent expresses the relative importance of criterion j in relation to the previous criterion (j-1) for each given criterion. This physical ratio is called the comparative importance of average value, sj.

Step 3. Determination of the coefficient kj as in equation 1.

$$Kj=\begin{cases} 1, & j=1 \\ sj+1, & j>1 \end{cases} \qquad \textit{Equation 1}$$

Step 4. Determination of the recalculated weight qj as in equation 2.

$$qj=\begin{cases} 1, & j=1 \\ \dfrac{kj\text{-}1}{kj}, & j>1 \end{cases} \qquad \textit{Equation 2}$$

Step 5. The relative weights of the evaluation criteria are determined as in equation 3. Wj indicates the relative weight of the j-th criterion, while n indicates the number of indicators.

$$Wj = \frac{qj}{\sum_{K-1}^{n} qk} \qquad \textit{Equation 3}$$

AHP Method

The Analytic Hierarchy Process (AHP) is a structured method for decision making proposed by Thomas L. Saaty in the 1970s (Darko et al., 2019). It provides a framework for complex decisions by decomposing them into a hierarchical structure and systematically evaluating the relative importance of criteria and alternatives. Second, AHP is flexible and considers both quantitative and qualitative factors, allowing decision makers to incorporate personal judgments and preferences into their decision-making process. Finally, AHP provides sensitivity analysis that allows decision makers to examine the impact of changes in judgments or in the weighting of criteria on the overall decision so that they can assess the strength of the results and make more informed decisions.

Despite the advantages of the AHP method, it also has some weaknesses that need to be addressed. One of its major weaknesses is its reliance on subjective judgments. The accuracy of AHP results is highly dependent on the experience, biases, and consistency of decision makers. Second, the computational process in the AHP can be complex and time-consuming. It involves mathematical operations such as pairwise comparisons, matrix algebra, and eigenvector calculations. In addition, the complexity of the AHP method can sometimes lead to a lack of transparency in the decision-making process. Results can be difficult to interpret or explain to stakeholders. Despite these weaknesses, the AHP method can be a valuable tool for decision making in a variety of areas if used correctly.

The calculation process in AHP includes the following steps (Levon R. Hayrapetyan, 2019):

Step 1: Hierarchical structuring: identify the decision problem and divide it into a hierarchy of criteria and alternatives. The hierarchy should have an objective at the top, followed by criteria and sub-criteria.

Step 2: Pairwise comparisons: Evaluate the relative importance of the criteria and alternatives using pairwise comparisons.

Step 3: Calculate the weights: calculate the criteria weights by summing the scores of the pairwise comparisons. This is done using matrix algebra, where the judgments are organized into a matrix and a mathematical process called eigenvector computation is applied to obtain the weights.

Step 4: Consistency check: perform a consistency check to ensure the reliability of the judgments. The consistency ratio (CR) is calculated to evaluate the consistency of the pairwise comparisons. If the CR exceeds a predetermined threshold (usually 0.1), the judgments may need to be revised.

Step 5: Aggregation and decision making: Aggregate the weights of the criteria and alternatives to obtain an overall score or ranking. To do this, multiply the weights of the criteria by the corresponding ratings of the alternatives and add them together.

These two methods are used for importance and suitability to the research objectives and for calculating the weights of the categories and indicators.

3.5 Conclusion

This chapter provided a comprehensive overview of the study area, focusing on the Palestinian context. It examined the construction sector in Palestine, highlighting its importance and the challenges it faces in implementing sustainable construction practices. It also examined the Palestinian education sector and the critical relationship between education and sustainability. The chapter also addressed the specific aspects of school buildings, their impact on the environment, and the challenges of implementing sustainable practices in Palestinian schools.

In order to effectively analyze the Palestinian case study, various data collection methods were used. Expert questionnaires were used to gather insights and opinions from industry. In addition, data was collected on-site at the schools to gain a comprehensive understanding of the conditions and practices in the Palestinian schools. Indoor quality data was also collected to assess the environmental aspects of the school buildings based on students' opinions. The collected data were analyzed using SWARA (Standard Weight Assessment Ratio Analysis) and AHP (Analytical Hierarchy Process). These analytical tools facilitated the evaluation and prioritization of the various indicators and factors within the sustainability assessment.

Overall, this chapter set the stage for the subsequent chapters (4 and 5) by clearly outlining the study area, its challenges, and the data collection and analysis methods used. Through these powerful methods, the study aims to provide valuable insights into the sustainability performance of Palestinian schools and contribute to the development of effective strategies for sustainable building practices in Palestine.

Chapter 4 Sustainability Assessment Framework for Palestinian Public Buildings and Schools

4.1 Introduction

The Sustainability Assessment Framework for Palestinian Public Buildings and Schools is an important tool developed to guide sustainable development in Palestine. The first section presents the framework for assessing public buildings in Palestine. The main objectives and the list of indicators in the environmental, social, and economic fields are mentioned. The framework aims to promote sustainable practices, address environmental challenges, improve social aspects, and increase economic efficiency in public buildings. The next section calculates the weighting of indicators within the framework by examining expert opinions and using SWARA and AHP methodologies.

The third section looks at international frameworks for evaluating school sustainability. It provides an overview of these frameworks and their objectives while emphasizing the need to assess their compatibility with the Palestinian context. It highlights any scientific gaps and limitations, paving the way for the development of a framework for sustainable Palestinian schools. describes the use of the PSR (Pressure-State-Response) model as the basis for implementing the framework. It shows the distribution of pressure, state, and response indicators across the main pillars of environmental, economic, and social sustainability. The next section focuses on determining the weighting of indicators within the school framework. Expert perspectives and general opinions are explored to capture the relative importance and contribution of each indicator. This chapter sets the stage for subsequent discussions on the Palestinian Public Buildings and Schools Framework. It highlights the importance of comprehensive assessment, balance of indicators, and adaptation to the local context in order to promote sustainable development and improve the built environment in Palestine.

4.2 Assessment Framework for Palestinian Public Building

Since the application of the concept of sustainability in the construction sector is still in its infancy in developing countries, a major effort is needed to adapt international knowledge and experience in these countries. This section aims to fill this gap by developing a framework for assessing the sustainability of public buildings in Palestine. The framework includes the development of sustainability indicators for public buildings based on a review of the literature and the opinion of a panel of experts. It also presents the SWARA method for ranking and weighting the indicators.

4.2.1 The Objectives of the Public Building Assessment Framework

The objectives of the Sustainable Assessment Framework for Public Works in Palestine are:

- To provide a guide for public authorities. Developing an assessment framework can help establish clear requirements and standards that can be integrated into policies and regulations to promote sustainability at the government level.

- Identify areas for improvement and set priorities. The framework helps decision makers prioritize sustainability efforts by optimizing resource allocation and ensuring that efforts are focused on the most important areas.
- Knowledge Sharing and Replication. This objective aims to share best practices, lessons learned, and innovative approaches to assessing the sustainability of public buildings and contribute to broader regional or global sustainable development goals. By developing a framework that can be expanded and replicated in other developing countries facing similar challenges.
- Improve environmental, social, and economic aspects. The framework aims to reduce environmental impacts, promote well-being and security, foster social equity and inclusion, and improve economic efficiency. This goal is consistent with the broader Sustainable Development Goals and has positive impacts on the local community.
- Monitoring and Evaluation: develop mechanisms to monitor and evaluate the sustainability performance of public buildings in accordance with the Framework's guidance. This objective aims to track progress, identify areas of success, and address any shortcomings or challenges. By integrating monitoring and evaluation processes, the framework can provide continuous feedback and enable adaptive management for continuous improvement.
- Capacity Building and Awareness: this objective aims to increase understanding, knowledge, and skills related to sustainable practices in public buildings to ensure effective implementation and long-term sustainability.
- Promote local culture and heritage preservation. Incorporating sustainability practices that respect and honor local Palestinian culture, traditions, and heritage will foster a sense of pride and ownership among people in the community.

With these goals in mind, a framework for assessing the sustainability of public buildings in developing countries like Palestine can be effective in promoting sustainable development by addressing environmental, social, and economic challenges while ensuring long-term benefits to society.

4.2.2 The Environmental Indicators for Public Buildings

This part explains the categories and indicators for the environmental aspect in the sustainability of the public building assessment framework in Palestine. Table 4.1 summarizes these categories, namely: (I) Energy efficiency, (II) Water efficiency, (III) Green city, and (IV) Indoor environment quality.

Table 4.1. The Environmental indicators for public buildings in Palestine.

Category	ID	Indicator	Unit	Short Definition
Energy Efficiency	EE1	Primary Energy Consumption	kWh/m^2	The amount of energy consumed in various tasks other than heating and cooling, such as lighting, electrical equipment, etc.
	EE2	Renewable	kWh/m^2	Power generation on-site from various

		Energy Production		renewable sources, especially solar energy, to generate electricity
	EE3	Cooling Energy Consumption	kWh/m^2	The amount of energy consumed in air conditioning
	EE4	Heating Energy Consumption	kWh/m^2	The energy consumed in the heating system determines what type of energy is used: electricity, gas, etc.
Water Efficiency	WE1	Water Consumption	l/pr.yr	The amount of water consumed in the building.
	WE2	Hot Water Consumption	l/pr.yr	The amount of hot water consumed in the building.
	WE3	Irrigation Water Consumption	l/m^2.yr	The amount of water consumed in the building for irrigation purposes.
	WE4	Rainwater Harvesting	m^3/yr	The amount of rainwater collected and reused in the building for cleaning, flush water, and firefighting.
	WE5	Recycled Greywater	m^3/yr	The amount of greywater collected and reused in the building for cleaning, flush water.
	WE6	Connection To Public Sewage	0 or 1	The internal ducts of the building are connected directly and securely with the public sewers.
Green City	GC1	Greenspace	%	Use of vegetation to provide ambient outdoor cooling.
	GC2	Solid Waste Production	ton	Provision of solid waste collection and sorting services
	GC3	Greenhouse Gas Emission	%	Presence materials with a high green gas emission or contain substances that negatively affect the individual or the environment in the building.
Indoor Environment	IE1	Thermal Comfort	PMV & PPD	Achieve a high level of thermal satisfaction for users and the distribution of thermal areas in the building to increase energy efficiency.
	IE2	Humidity Comfort	%	Maintain a suitable and satisfactory humidity ratio for users to achieve thermal satisfaction in the building.
	IE3	Indoor Acoustic Comfort	Dp & STC value	All populated rooms or areas must remain within the permissible limits for transmitting sound to and from an occupied place.
	IE4	Indoor Air Quality	CO_2 Level	Provide the necessary amount of outdoor and fresh air for the users

				inside the building.
	IE5	Safety and Security	Scale (1-5)	Ensure that the building is safe and can face earthquakes, floods, and fires while providing public safety requirements.

Energy efficiency

The energy efficiency of buildings has become a critical concern in the building's life cycle management. As mentioned before, the building sector constitutes a significant consumer of energy in the world. Energy consumption is also associated with excessive use of resources. Moreover, the energy production process is responsible for harmful and toxic emissions into the atmosphere (Akhanova et al., 2019). Therefore, most assessment tools focus on energy management (Shad et al., 2017a). Energy has the highest weighting among the other categories with 25% and 21% scores in the LEED and BREEAM sustainable rating systems, respectively.

The energy category for Palestine is particularly critical because Palestine suffers from deprivation from exploiting its natural resources, such as the production or import of electricity and natural gas. The energy efficiency category includes four indicators: (EE1) Primary energy consumption, (EE2) Renewable energy production, (EE3) Air conditioning energy consumption, and (EE4) Heating energy consumption and type of energy.

Water Efficiency

Water scarcity is a major challenge in Palestine due to significant damage to water resources and infrastructure (Road, 2017). Consequently, the Authority is concerned with improving the water efficiency system. In addition, it is necessary to consider new water sources such as rainwater harvesting and graywater treatment. The policy for the water efficiency category is based on six indicators: (WE1) water consumption, (WE2) hot water consumption, (WE3) irrigation water consumption, (WE4) amount of rainwater harvesting, (WE5) reused graywater, and (WE6) connection to public sewer.

Green city

Green spaces are an essential factor in the quality of life. Given the high density of development in urban areas, they play a crucial role in achieving the goal of a green city. Palestine is in dire need of green spaces because it suffers from a shortage of land, as mentioned earlier. Three indicators are used for the contribution of public buildings to the green city: (i) the percentage of green spaces (GA1), (ii) the generation of solid waste (GA2), which aims to reduce construction waste by sorting solid construction waste for secondary use and recycling, and (iii) the reduction of greenhouse gas emissions, which is considered one of the priorities for the sustainable development of any country.

Indoor Environment Quality

This category aims to improve the quality of the internal environment to maintain the health and comfort of users and increase productivity (Mokhtarmanesh & Ghomeishi, 2019). Most people spend about 90% of their time indoors (Akhanova et al., 2019). According to the Palestine Higher Green Building Council (2013), improving the indoor environment could (i) reduce the number of days lost due to illness by an average of 3 days per person per year and (ii) increase individual productivity by about 5%. This category is second only to energy, with 22% and 15% in the sustainable rating systems LEED and BREEAM, respectively. This category includes five indicators: (IE1) Thermal Comfort, (IE2) Humidity Comfort, (IEQ3) Indoor Acoustic Comfort, (IE4) Indoor Air Quality, and (IE5) Safety and Security.

4.2.3 The Social Indicators for Public Buildings

This category focuses on the social services of public buildings. They are important for understanding the needs of the population and achieving long-term collective well-being (Pardo-Bosch et al., 2019). It contributes to improving inclusion, equity, employment, safety, education, satisfaction, participation, and accessibility to public services. It must also ensure that community values are incorporated into the decision-making process. (Tammy et al., 2017) have shown that the rating system does not consider the social dimension of buildings. Moreover, building codes in Palestine completely ignore these indicators despite their importance in improving the social environment.

Table 4.2 summarizes the list of indicators for the social category. It includes five indicators. The public transportation indicator (SA1) concerns the accessibility of the building for the members of the society, especially for disabled people. It promotes the location of the building near public transportation. The second indicator concerns the use of public facilities for social activities (SA2). The third indicator measures the daily occupancy of the building (SA3), while the fourth indicator focuses on the hourly occupancy of the building (AS4). The last indicator is related to cultural heritage (AS5).

Table 4.2. The Social indicators for public buildings in Palestine.

Category	ID	Indicator	Unit	Short Definition
Social Issues	SA1	Accessibility and closest to public transportation	m	The building is available to all ages and members of society, especially the disabled, and near public transportation.
	SA2	Use for social activities	Scale (1-5)	The building can be used for community activities outside of official working hours.
	SA3	Daily Occupation rate	person/day	Intensive daily use of the building.
	SA4	Hourly Occupation rate	person/hour	Intensive hourly use of the building.
	SA5	Culture and	Scale (1-5)	Develop the site to fit its job and

	Heritage	protect the culture of a community.

4.2.4 The Economic Indicators for Public Buildings

Although the economic factor is considered crucial in developing countries, it is not yet implemented in the building codes there (Shad et al., 2017a; Tammy et al., 2017). Also, the economic dimension is not central to BREEM, LEED, GBTool and CASBEE. Therefore, it is important to include the economy aspect clearly in the frameworks for assessing sustainability in public buildings. Palestine suffers from difficult economic conditions that require the development of guidelines that contribute to reducing the operational cost of buildings, which will benefit the government and the people.

The economic category concerns the total building operations and maintenance costs. It includes two indicators, as shown in Table 4.3: (i) The Operational energy expenses (EC1), which covers services related to heating, cooling, lighting, and others, and (ii) the Operational water expenses (EC2), which covers services such as potable water, flush water, cleaning, and irrigation.

Table 4.3. The economic indicators for public buildings in Palestine.

Category	ID	Indicator	Unit	Short Definition
Economic Aspect	EC1	Operational Energy Expenses	$/yr	The cost required to operate all services requires energy, such as heating, cooling, lighting, etc.
	EC2	Operational Water Expenses	$/yr	The cost required to operate all services requiring water, such as potable water, flush water, cleaning, and irrigation

4.2.5 Refining the Sustainability Framework for Public Building

It is necessary to make the framework more comprehensive by considering certain types of public buildings. It is important to recognize that public buildings include a variety of structures, including schools, universities, offices, stores, gymnasiums, hospitals, and houses of worship. Each type serves different societal needs and therefore requires somewhat different sustainability requirements, particularly with regard to social issues. In addition, there is a recognized need for a more systematic approach to the presentation of categories and indicators within the framework. This includes a thorough understanding of the underlying causes, measurement methods, and appropriate response strategies to effectively address these causes and their impacts.

Therefore, it was decided to develop a sustainability assessment framework specifically for Palestinian schools. The Pressure, State, and Response (PSR) Modal method was chosen to make the framework more comprehensive, systematic, and clear. By using this method, the framework aims to provide a comprehensive assessment of sustainability in Palestinian schools that covers a variety of aspects in a structured and easy-to-understand manner. These improvements are explained in the following sections, which describe the components of the framework and its application in the context of Palestinian schools.

4.3 The Weights of Public Building Indicators

This section presents the results obtained through a process that involved experts' opinions and the utilization of SWARA and AHP methodologies. These methods enable a systematic analysis of the relative importance of different sustainability categories and indicators. By combining expert insights and quantitative analysis, we can establish a robust framework that guides sustainability assessments and decision-making processes effectively.

4.3.1 Experts' Profile and General Opinions

The indicators defined in the previous section were submitted to a panel of experts for evaluation and extension by means of a questionnaire. This approach was used by (Olawumi & Chan, 2018) to identify and prioritize sustainability practices in construction projects. They also reported that it helped to reach consensus on complex projects. Experts were selected based on their experience and expertise in the construction sector and in sustainable and green buildings. Twenty-nine (29) responses were received from experts. Table 4.4 provides an overview of the profile of these experts. About 60% of them have a PhD degree. They cover extensive construction activities, such as architecture, civil engineering, mechanical engineering, management and urban planning, and environmental engineering. About 55% of the experts are architects. About half of the experts work in the public sector, the other half in the private sector.

Table 4.4. The experts' personal information.

Experts' Personal Information			
		Classification	**No.**
1	**Gender**	Male	23
		Female	6
2	**Education Level**	Bachelor	6
		Master	6
		PhD	17
3	**Specialization**	Architecture	16
		Civil and building engineering	7
		Management and urban planner	3
		Mechanical and energy engineering	3
4	**Working Sector**	Public Sector	14
		Privet Sector	15

Table 4.5 shows the heat map of the evaluation of the indicators by the 29 experts. It shows that the majority of experts (around 66%) gave a high score (S = 4) to a very high score (S = 5), while only 10% gave a very low (S=1) to low (S = 2) scores to the set of indicators. Around 24% of the experts gave an intermediate score (S = 3). However, the global score varies between 99 (use of the buildings for social activity) to 127 (thermal comfort), with a mean value of 113 and a standard deviation of 10.5.

Table 4.5. Heat-map results of public building categories and indicators.

Category	ID	Indicator	Scale for Quantitative Parameters 1 to 5 (1 Less important, 5 More important)					Global Score
			1	2	3	4	5	
Energy Efficiency	EE1	Primary energy consumption	0	1	5	6	17	126
	EE2	Renewable energy production	0	2	4	7	16	124
	EE3	Cooling energy consumption	0	3	5	5	16	121
	EE4	Heating energy consumption	0	1	5	7	16	125
Water Efficiency	WE1	Water consumption	0	0	3	13	13	126
	WE2	Hot water consumption	3	3	8	8	7	100
	WE3	Irrigation water consumption	2	3	9	10	5	100
	WE4	Rainwater harvesting	1	1	7	12	8	112
	WE5	Recycled greywater	2	2	9	10	6	103
	WE6	Connection to public sewage	0	5	5	5	14	115
Green City	GC1	Greenspace	0	2	6	6	15	121
	GC2	Solid waste production	1	0	4	14	10	119
	GC3	Greenhouse gas emission	1	3	8	7	10	109
Indoor Environment	IE1	Thermal comfort	0	0	8	2	19	127
	IE2	Humidity comfort	0	2	8	10	9	113
	IE3	Indoor acoustic comfort	0	3	9	13	4	105
	IE4	Indoor air quality	0	1	6	4	18	126
	IE5	Safety and security	1	2	3	6	17	123
Social	SA1	Accessibility and closest to public transportation	1	3	6	11	8	109
	SA2	Use for social activities	1	5	9	9	5	99
	SA3	Daily occupation rate	0	3	13	8	5	102
	SA4	Hourly occupation rate	1	3	11	10	4	100
	SA5	Culture and heritage	0	6	8	10	5	101
Economic	EC1	Operational energy expenses	0	1	7	5	16	123
	EC2	Operational water expenses	2	3	8	11	5	101

4.3.2 Weights of Public Buildings Categories

Table 6 shows the rank and weight of each category of indicators as calculated by the SWARA method, as well as the scores in Table 4.6. According to the experts, energy

efficiency and indoor climate received the highest rank, which means that these categories are most important for the sustainability of public buildings. This result is consistent with the importance of energy in international sustainability certificates. It also highlights the importance of energy in Palestine due to the lack of resources. The experts also emphasized the importance of indoor climate in public buildings both for the health and productivity of employees and for the comfort of users. The social dimension received the lowest ranking. In the Palestinian context, this dimension is not considered an important issue by the experts.

Table 4.6. Ranks and weights of the public building categories according to the experts' opinion and the SWARA method.

Sustainable Categories	Global Score	Rank	Comparative Importance of average value (sj)	Coefficient (Kj)	Recalculated weight	Weight
Energy Efficiency	124	1		1	1	**0.184**
Indoor Environment	119	2	0.05	1.05	0.95	**0.175**
Green City	116	3	0.03	1.03	0.92	**0.170**
Economic	112	4	0.04	1.04	0.89	**0.163**
Water Efficiency	109	5	0.03	1.03	0.86	**0.159**
Social Aspect	102	6	0.07	1.07	0.81	**0.148**

Table 4.7 shows the weighting of sustainability categories in the Palestinian Green Building Guideline (PGBG). It shows that this guideline does not consider the social and economic categories. It agrees with the experts' opinion on the importance of energy efficiency, but gives a higher priority to water than the experts. This difference could be related to the low water consumption in public buildings. Nevertheless, both the PGBG and the experts agree with the importance of the sustainability category in the context of indoor climate.

Table 4.7. The weight of sustainability categories in the Palestinian Green Building Guideline (PGBG) (Palestine Higher Green Building Council, 2013).

PGBG Sustainability Categories	Weight
Energy Efficiency	0.30
Water Use Efficiency	0.25
Indoor Environment	0.15
Site Sustainability	0.15
Materials and Resources	0.10
Innovation and Building Integrated Design	0.05

4.3.3 Weights of Public Buildings Indicators

Table 4.8 shows the rank and weighting of the indicators for the environmental aspect. It can be seen that the indicators for energy efficiency are close to each other and consequently they

are also weighted closely. Therefore, the experts believe that these indicators are of almost equal importance and should be considered when evaluating the sustainability of public buildings. In the water efficiency category, total water consumption receives the highest weighting, followed by the connection of buildings to the public sewer system. Rainwater harvesting also receives a high weighting, indicating the importance of this issue in Palestine due to water scarcity. In contrast, the consumption of hot water and water for irrigation received the lowest weighting, as they are hardly used in public buildings.

Green space and solid waste generation received high and low weights, respectively, while greenhouse gas emissions received low weights. This result shows that greenhouse gas emissions are not yet considered a major environmental problem by the experts. As for indoor climate indicators, experts in public buildings gave high priority to thermal comfort, air quality and safety, which received high and close ratings. Humidity and acoustic comfort, on the other hand, are considered less important.

Table 4.8. The weights of public building indicators of environmental aspect.

Indicators' Weights of Environmental Aspect			
Category	Indicator	Score	Weight
Energy Efficiency	EE1 (Primary energy consumption)	126	0.255
	EE4 (Heating energy consumption)	125	0.253
	EE2 (Renewable energy production)	124	0.250
	EE3 (Cooling energy consumption)	121	0.243
Water Efficiency	WE1 (Water consumption)	126	0.195
	WE6 (Connection to public sewage)	115	0.173
	WE4 (Rainwater harvesting)	112	0.171
	WE5 (Recycled greywater)	103	0.157
	WE2 (Hot water consumption)	100	0.152
Green City	GC1 (Green space)	121	0.348
	GC2 (Solid waste production)	119	0.342
	GC3 (Greenhouse gas emission)	109	0.311
Indoor Environmental Quality	IE 1 (Thermal comfort)	127	0.216
	IE 4 (Indoor air quality)	126	0.214
	IE 5 (Safety and security)	123	0.208
	IE 2 (Humidity comfort)	113	0.189
	IE3 (Indoor acoustic comfort)	102	0.175

Table 4.9 summarizes the results related to the social and economic indicators. Accessibility and proximity to public transportation received the highest weighting, while the other indicators received closed scores. For example, the occupancy rate of public buildings and their use for social activities are ranked as low in importance. In the economic category, spending related to energy consumption is considered very important, while spending related to water consumption is less important. This result could be related to the low water consumption in public buildings compared to water consumption in residential buildings.

Table 4.9. The weights of public building indicators of social and economic aspect.

Indicators' Weights of Social and Economic Aspects			
Category	**Indicator**	**Score**	**Weight**
Social Aspect	SA1 (Accessibility and closest to public transportation)	109	0.214
	SA3 (Daily Occupation Rate)	102	0.200
	SA5 (Culture and Heritage)	101	0.198
	SA4 (Hourly Occupation Rate)	100	0.196
	SA2 (Use for Social Activities)	99	0.194
Economic Aspect	EC1 (Operational Energy Expenses)	123	0.549
	EC2 (Operational Water Expenses)	101	0.450

4.4 International Sustainability Assessment Framework for Schools

Nowadays, many countries have implemented and developed frameworks and tools for buildings sustainability assessments. These frameworks and tools were created for various types of construction including residences, offices, hospitals, sports centres, and commercial buildings. Since few of them were proposed for schools, this research aims at filling this gap through the development of a framework for sustainability schools.

4.4.1 Overview of the Sustainability School Frameworks

Sustainability assessment tools are essential tools for evaluating and monitoring schools' sustainability performance. This is because they provide a structured framework to measure, track, and improve environmental, social, and economic aspects of sustainability in educational institutions. This review aims to examine existing tools for assessing school sustainability, explore their strengths and limitations, and identify scientific gaps in the field.

Categories and indicators related to sustainability and schools can be found in specific international tools, such as:

1. LEED for Schools: The Leadership in Energy and Environmental Design (LEED) is the most used methodology worldwide. This rating system includes a specific category for schools, evaluating sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation. The list of categories and indicators of the LEED for Schools are presented in Table 4.1 in Appendix 4.
2. BREEAM Education: The Building Research Establishment's Environmental Assessment Method (BREEAM) offers an assessment tool for the following educational buildings: schools, colleges, pre-school, institutions such as the learning resource centres, student union, teaching facilities, laboratory/workshop/studio, student residential accommodations or a mixture of these types. This tool is considering factors such as energy, water, health and well-being, pollution, materials, management, and site ecology. Table 4.2 in Appendix 4 presents the list of categories and indicators of the BREEAM Education 2008.

3. The SBTool for K12 school: The Sustainable Building Tool is to evaluate the sustainability performance of K12 educational facilities. The SBTool provides a comprehensive framework for assessing and benchmarking sustainability in school buildings, considering factors like site development, energy and resource consumption, environmental loadings, indoor environmental quality, service quality, social and cultural aspects, and cost and economic aspects. The list of categories and indicators of the SBTool for K-12 Schools are presented in Table 4.3 in Appendix 4.
4. Eco-Schools: Eco-Schools, which operated by the Foundation for Environmental Education, is an internationally recognized program that engages students, teachers, and the wider community in sustainability initiatives. It covers various aspects of sustainability, including waste management, energy conservation, biodiversity, and sustainable transportation.

In addition, there are many local initiatives for different countries to create tools to assess the eco-schools, presented in Table 4.10. Most indicators assess the overall process of full implementation (UNEP; Australian Government; Eco-Schools USA; MEP in China; MECSST in Japan), while some indicators adhere to technology evaluation (CASBEE in Japan).

Table 4.10. Worldwide tools and indicators for evaluating schools (Source: (Chen et al., 2018)).

Country or region	Topic or indicator	Content
United Nations Environment Programme's (UNEP) (2015)	Seven steps towards an Eco school	Form an Eco Committee
		Carry out an Environmental Review
		Action Plan
		Monitor and Evaluate
		Curriculum Work
		Inform and Involve
		Produce an Eco Code
Australian Government (2005)	Indicators for a sustainable school	Educational
		Environmental
		Water
		Electricity
		Waste
		School grounds
		Social
		Economic
ECO-Schools USA (2017)	Pathways to Sustainable Development	Investigate and increase biodiversity at school and
		beyond
		Improve climate literacy and investigate climate change
		solutions
		Moving beyond the “3Rs”
		Analyze and measure effective

		ways to conserve energy
		Promote a healthy lifestyle while connecting to the
		natural world
		Find relationships between human health and the
		building and grounds
		Design, develop and maintain an outdoor learning
		laboratory
		Improve food education and nutrition opportunities at
		school
		Outline alternative school transportation methods to
		reduce the school's carbon footprint
		Analyze and measure effective ways to conserve water
		Learning About Forests
Ministry of Environmental Protection (MEP), China (2017)	Assessment Standards for Eco-Schools	Form a leadership institution
		Support from school
		Management measures
		Complete document
		Environmental education courses involved
		Environmental education researches
		Develop an environmental education atmosphere
		Disseminate green lifestyles
		Green landscaping campus
		Establish an environmental committee
Ministry of Education, Culture, Sports, Science and Technology (MECSST), Japan (2017)	Assessment and certification tools for school buildings	Energy efficiency
		Resource efficiency
		Local environment
		Indoor environment.
Taiwan Architecture & Building Centre. Ecology, Energy Saving, Waste Reduction and Health (EEWH), Taiwan (2017)	Assessment and certification tools for buildings	Biodiversity
		Greenery
		Soil Water Content
		Energy Conservation
		CO_2 Emission Reduction
		Construction Waste Reduction
		Indoor Environment Quality
		Water Conservation
		Sewage and Garbage

4.4.2 Scientific Gap in these Frameworks

While several tools exist to assess school sustainability, there are still significant scientific gaps that need to be addressed for further progress in this area.

1. Comprehensive and holistic assessment: existing tools often focus primarily on environmental aspects such as energy and water efficiency and pay less attention to the social and economic dimensions of sustainability. Although the SBTool for K-12 schools balances the three dimensions of sustainability, there is no specific indicator for environmental education, which is part of the Education for Sustainability category.

2. Adaptability to different contexts: many assessment tools are designed for specific regions or countries, which limits their applicability in different educational contexts.

3. Robust measurement and verification: there is a need for standardized protocols and methodologies to ensure accurate and reliable data collection, measurement, and verification of sustainability indicators. Establishing a robust measurement framework will improve the credibility and comparability of assessment results.

4. Longitudinal studies and impact evaluation: While sustainability assessment tools provide valuable snapshots of school sustainability performance, longitudinal studies and comprehensive impact assessments are lacking. Future research should focus on examining the long-term impact of school sustainability initiatives and their influence on student behavior, academic achievement, and community engagement.

Our focus is on filling the first two gaps: holistic assessment and adaptability to different contexts. Thus, our research aims to develop comprehensive and holistic assessment tools that capture the full range of sustainability indicators. In addition, the research aims to develop an assessment tool that is appropriate for the unique characteristics and priorities of Palestinian schools. It can also be adapted to different school environments around the world.

4.5 Framework for Palestinian Sustainable Schools

This section outlines the objectives and scope for developing a sustainability assessment tool for schools. It also shows the hierarchy of this tool, starting with sustainability criteria and ending with indicators by using the PSR Model. Explains the importance of each one and its interdependence with the reality of Palestinian schools. Then the process of analysing experts' opinions is shown to determine the weights and importance of these indicators.

4.5.1 The Objectives of the School Assessment Framework

The goals of the sustainable assessment framework for schools are:

- Promote sustainable performance. Enable schools to assess their current sustainability performance, set goals, and track progress toward those goals.
- Prioritize sustainability efforts. Facilitate the identification of areas where schools can make significant improvements and assist decision makers in prioritizing sustainability initiatives.

- Promote stakeholder communication: enable schools to communicate their sustainability efforts to stakeholders in a credible and meaningful way. This goal promotes transparency, builds trust, and engages the broader community in supporting and participating in sustainable practices in Palestinian schools.
- Incentivize sustainable leadership. This goal encourages schools in Palestine to become sustainability leaders, inspire others to do the same, and promote a culture of sustainability in the education sector.
- Promote student engagement and ownership: by encouraging student participation in sustainability, the goal is to increase their awareness and knowledge so that they can become agents of change and advocate for sustainable practices.
- Improve health and well-being, increase resource efficiency, and save money.

By focusing on these goals, the Sustainability Assessment Framework for Schools in Palestine can bring about positive change, improve resource management, promote environmental stewardship, and contribute to the well-being of students, staff, and society at large.

4.5.2 The PSR Environmental Indicators for Schools

Buildings have a significant impact on the environment as they consume resources, produce waste, and release emissions into the atmosphere throughout their life cycle (Kamaruzzaman et al., 2016). Buildings are one of the largest sources of carbon dioxide emissions and global warming. Therefore, the aspects of environmental sustainability in the context of the Palestinian school include five criteria, namely energy efficiency, water efficiency, indoor quality, waste management, and site development, as shown in Table 4.11.

Table 4.11. The PSR environmental indicators for schools.

Pressure Criteria	State indicators	Unit	Response indicators	Unit
Energy Efficiency	Heating Consumption	kWh/m².yr	Energy Efficient Heating Equipment Management system	kWh/m².yr
	Cooling Consumption	kWh/m².yr	Energy Efficient Cooling Equipment	kWh/m².yr
	Lighting Consumption	kWh/m².yr	Energy Efficient Lighting System	kWh/m².yr
	Building Envelope	U value	Wall Insulation	U value
			Roof Insulation	U value
			Glazing	U value
			Shading Devices	Scale (1-5)
	Renewable Energy Production	kWh/m².yr	Solar Panels	KWh/m².yr
Water Efficiency	Total Water Consumption	L/student.yr	Number of Students	L/student.yr
			Internal Leak	
	Supply Water Consumption	L/student.yr	Rainwater Harvesting	L/student.yr
			Recycled Grey water	

	Connection to Public Sewage	Scale (1-5)		
Indoor Quality	Thermal Comfort	PMV & PPD	Heating/Cooling System	KWh/m²
			Global Insulation	Scale (1-5)
			Ventilation	ach/hour
	Visual Comfort	lux	Natural and Artificial Lighting	lux
			Wall-Window Ratio (view)	%
			Glare	GI
	Acoustic Comfort	dp value	Acoustic Insulation	dp value
	Indoor Air Quality	CO_2 level	Ventilation Equipment	L/pr/hr
	Safety	Scale (1-5)	Respect the Safety Guidelines	Scale (1-5)
			Training Classes	Scale (1-5)
Waste Management	Waste Management	0 or 1	Solid Waste Separation	0 or 1
			Grey Water Recycling	0 or 1
Site Development	Green Area	%		
	Heat Island Effect	ΔT	Low SRI Surface	%
	Shading Area	%		

1. Energy Efficiency

According to the latest IPCC report, energy use and associated greenhouse gas emissions from buildings could double or even triple by 2050 due to several major trends, including population growth, urbanization, changes in family size, and behavioral changes. School buildings have always been the target of energy conservation interests. This is because energy efficiency, along with indoor comfort, are the most important characteristics of a well-functioning school based on the principles of sustainable architecture (Antunes & Ghisi, 2020).

Energy performance in school buildings is evaluated by assessing the condition of the indicators, i.e., the HVAC system, external and internal lighting, and the building envelope, to determine how much energy savings could be achieved. Other energy saving methods and renewable energy technologies play an important role in the assessment schemes to find more sustainable ways of energy use. Although Palestinian schools do not use heating or cooling systems such as HVAC systems, they were included in the assessment. This is because, in line with future aspirations, it is possible to use these resources to increase the comfort of students and school staff.

2. Water Efficiency

Due to population growth and the resulting increase in demand for this resource, there is growing concern about water scarcity. Therefore, the rational use of water in buildings is

becoming increasingly necessary. Schools are among the types of buildings that consume large amounts of water (Antunes & Ghisi, 2020). Therefore, in this category, water consumption must be reduced by eliminating the use of potable water in landscaping, innovative treatment and wastewater use, and reducing the use of municipal water supply.

Water use in schools varies widely across countries. In Brazil, for example, water consumption varies between (0.51 – 81.1) L/student/day (Antunes & Ghisi, 2020). (Almeida et al., 2015) analyzed water consumption in 23 schools in Portugal and found significant differences, even in schools with similar characteristics, suggesting that user behavior plays an important role in efficiency. In Palestine, (Shuraideh, 2015) found that water consumption in elementary school varied between (3.38 - 4.67) l/student-day, in female secondary schools it was about (4.86) l/student-day, and in male secondary schools it was (6.3) l/student-day. Due to the large differences depending on the method used, the type of facilities and the habits of the users, different measures can help to reduce water consumption, such as social and technical measures. Social measures occur through education campaigns, user awareness, and individual behavioral changes. Technological measures include replacing conventional appliances with water-efficient ones, using rainwater, and reusing graywater.

Energy and water efficiency benefits schools in many ways: financially, educationally, socially, and environmentally.

- It reduces water and energy costs, which means you can do more with the school budget.
- It provides excellent leadership opportunities and hands-on learning activities for students.
- Builds a strong school culture based on good communication and shared goals.
- Contribute to a better environment through efficient energy and water use. You will do your part to build a better and more sustainable planet now and in the future.

3. Indoor Environmental Quality (IEQ)

Indoor environmental quality (IEQ) in educational buildings has a major impact on the health of students, who may develop a range of non-specific symptoms in an unhealthy building. Therefore, IEQ is a common theme of all sustainable development assessment tools that aim to improve the comfort, health, and safety of a building's occupants. In most school sustainability assessments, such as LEED for schools, BREEAM Education, and SBTool for schools, the condition indicators are: thermal comfort, indoor air quality, acoustic comfort, level of ventilation and pollution, visual comfort, and safety.

These condition indicators establish a link between the quality of the educational environment and student performance (Baghdadi, 2022):

1. Fresh air (air quality): reduces the risk of diseases, including asthma, which is one of the main reasons for school absenteeism.

2. Noise: research has demonstrated that students are more productive, happy, and learn more effectively when they are not distracted by noises from outside or from surrounding spaces and occupants.
3. Thermal systems: for thermal comfort design must balance energy efficiency, clean air, and minimal background noise.
4. Visual comfort: scientific research emphasizes that students can achieve 5-14% higher test scores and learn 20-26% faster with high visual comfort.

4. Waste Management

In general, schools produce a wide range of waste, including food waste, paper, sanitary waste, electrical and electronic equipment (WEEE), plastics, furniture, and glass. In the UK, for example, elementary school produce about 45 kg of waste per pupil, while secondary schools produce 22 kg per pupil. This adds up to 250,000 tons of waste per year (Defra, 2018). This can be a unique challenge when it comes to managing everything in a convenient, sustainable and cost-effective way. Understandably, many schools dispose of their waste en masse as this is the easiest solution. Therefore, the school should prioritize two things: reducing waste production and adopting a recycling culture. Waste separation, waste reduction, recycling, and composting are good options for waste management. School administrators must find ways to dispose of school waste with minimal negative impact on the environment. Waste separation is the first step in school waste management. Clearly labeled boxes should be available for glass, paper, plastic, cans, and organic waste. Recycling of waste within the school should be considered. Recycling gray water in schools reduces water consumption. Recycling educates good practices at work and at home.

5. Site Development

Site development is an important component of building sustainability (Council, 2019). This category aims to reduce the building’s impact on ecosystems and promotes regionally appropriate landscaping. It promotes the reduction of erosion, light pollution, heat island effect, and building-related pollution. This category consists of the three main indicators of condition: green spaces, heat island effect, and shaded areas.

Green spaces can greatly enhance the mental, physical, and social development of children from infancy to adulthood (Armenia, 2021). A green view from a school's windows correlates with better academic performance and student concentration. Heat islands occur when there are dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat. This effect leads to increased energy costs (e.g., for air conditioning), air pollution, and heat-related illnesses. Therefore, materials with a low solar reflectance index (SRI) must be used to reduce the heat effect.

Shading structure is an important and valuable addition for schools. Shading of outdoor areas can:

- Protect students and staff from the sun's harmful UV rays,
- help prevent sunstroke and other heat-related injuries,

- lower ambient temperatures by up to 20 degrees,
- Protect outdoor furniture and playground equipment from high temperatures,
- Add distinctive patterns with school colors and logos,
- Enable outdoor learning and activities and provide additional opportunities for fresh air and social distance.

However, it is very important to build these shade structures in a way that does not conflict with passive design strategies, such as allowing the sun into classrooms in the winter.

4.5.3 The PSR Social Indicators for Schools

The social aspect of school is very important. Because in school we learn to live with and for society. The social dimension of schools is less considered than the economic and environmental dimension (Stender & Walter, 2019). In general, public projects do not consider the social aspects, but focus on environmental and economic performance (Sierra et al., 2018). Therefore, the social sustainability aspects in the Palestinian school framework include five criteria, namely social equity, health and comfort, social cohesion, accessibility, and teaching quality, as shown in Table 4.12.

Table 4.12. The PSR social sustainable indicators for schools

Pressure Criteria	State indicators	Unit	Response Indicators	Unit
Social Equity	Social Inclusion	%	The ratio of low-income people	%
			Adaptation for disabled students	Scale (1-5)
	Human Centred Design	Scale (1-5)	Teachers Participation	Scale (1-5)
			Parents Participation	Scale (1-5)
			Students Participation	Scale (1-5)
Health and Comfort	Occupants Health	%	Absence Rates	%
			The appearance of Sick Building Syndromes/BRI	# of Symptoms
	Ergonomic Comfort	Scale (1-5)	Appropriate classroom furniture design and arrangement	Scale (1-5)
			Appropriate colour in the educational environment	Scale (1-5)
Social Cohesion	Social Interaction	Event/yr	School Services	Scale (1-5)
	Cultural Value	Scale (1-5)		
Accessibility	Access to Public Transportation	m		

	Access to Non-Motorized Mode of Movement	0 or 1		
	Parking Area	%		
Teaching Quality	Success Rates	%	Governance policy	Scale (1-5)
	Attendance Rates	%	student/teacher	ratio
	Discipline Referrals	#/yr (%)	Occupation rate	Student /m²
	School Dropout	#/yr (%)		

1. Social Equity

Equity is the provision of personalized resources that fit their circumstances. In other words, the goals and expectations are the same for all students, but the support needed to achieve those goals depends on the needs of the student. Most schools focus on horizontal equity, meaning they treat students who are already considered equal in the same way. However, in most schools, students come from different backgrounds and some enjoy more privileges than others. Therefore, teachers need to focus on vertical equity, where individual resources are provided based on student needs.

Social justice challenges in schools include many factors such as race, gender, poverty, family crises, mental health issues, and lack of healthcare. Identifying and analyzing the issues that prevent students from succeeding is the first step to solving these problems. This benefits students and the school environment as well as the community. Equity is linked to greater social cohesion and leads to long-term economic growth. Strengthening equity in schools is the most effective social investment.

This indicator can be achieved through two state indicators: social inclusion and human-centered design. Social inclusion is the process of improving the conditions for student participation in schools and enhancing the abilities, opportunities, and dignity of disadvantaged people, particularly low-income students and those with disabilities. People-centered design is a problem-solving approach that places people (stakeholders) at the center of the development process. The key stakeholders needed in this approach are students, teachers, and parents.

2. Health and Comfort

Children spend more time at school than anywhere else except home. Inadequate environmental conditions can have short- and long-term health effects and affect children's productivity and ability to learn. Children are more susceptible to disease and the effects of pollution than adults (Bluyssen, 2016). As a result, many studies have been conducted around the world in recent decades to document classroom indoor environments and examine associations with disease and disorders. (Bluyssen et al., 2018) emphasized that health and comfort were better in non-traditional schools than in traditional schools. A non-traditional school is a school in which the method of teaching children differs from the traditional method of education, according to a different educational theory. In addition, it confirmed a

strong relationship between physical building characteristics (heating system, solar shading devices that impede window opening or ventilation, window frame corners, flooring, and cleaning frequency) and classroom symptom index and classroom comfort index.

This category focuses on two condition indicators: occupant health, which describes how the building helps reduce infections and illnesses and facilitates rapid recovery. The second is ergonomic comfort, which focuses on creating a comfortable workspace and how students interact with their work environment.

3. **Social Cohesion**

This category focuses on the importance of the social and physical integration of the school into society. The school should promote the concept of participation and preservation of traditions in society. This helps to create environmental, social and economic benefits for the school in particular and society in general. In addition, it is necessary to create a positive school culture for both students and teachers. When the school has a positive culture, teachers are motivated to work because they see the big picture. Students are in a better mental and emotional state to learn. Success, enjoyment, and achievement are considered key characteristics of a positive school culture. A wide range of factors, from individual characteristics to community level, influence perceptions of cohesiveness. This research focuses on social interaction to maintain the cultural value of society and enhance a positive school culture.

4. **Accessibility**

This category is concerned with easy access to school, regardless of the type of transportation used. The location of the school should be as close to the public transportation services. This helps encourage the use of public transportation rather than private transportation. In addition, this category focuses on the importance of providing car parks separate from student movement corridors, playgrounds, and other school facilities that are used by students.

5. **Teaching Quality**

Quality instruction is one of the school's main pillars for improving student achievement. Supporting each teacher in delivering quality instruction is critical to achieving the best outcomes for all students, especially the most disadvantaged among them. The success rate, attendance rate, number of expulsions and dropouts are the characteristics used to evaluate this category.

4.5.4 The PSR Economic Indicators for Schools

Scientific research has shown that the quality level of educational activities influences the quality of economic, political, social and cultural development of the society. Moreover, societies establish a link between increasing the level of education and productivity, believing that an individual contributes as much to society as he or she receives in education. According to educational economists, education is the key to economic growth. The purpose of education is to meet all kinds of demands and needs of both society and individuals.

The relationship between education and the economy can be summarized as follows (Pekkolay, 2021):

1) Education raises the manpower needed by the economy (contribution to production).
2) There is a certain cost of operating and benefiting from the education service (training cost).
3) There is a relationship between education and finance.
4) Education has an impact on income generation at the individual (micro) and societal (macro) levels.
5) Education service has the property of being a commodity.

The effects of education on economic growth are assessed by two state indicators: public spending on education per student and the index of unemployment rates with advanced education, as shown in Table 4.13.

Table 4.13. The pressure, state, and response economical sustainable indicators for schools.

Pressure Criteria	State indicators	Unit	Response indicators	Unit
Annual Operating Costs	Operational Expenses	$/m².yr $/st.yr	Operational Energy Expenses Operational Water Expenses Maintenance Cost	$/m².yr
Impact on Local Economy	Creating Jobs/ Employment	job/yr		
	Production Activity	$/yr		

1. Annual Operation Cost

The willingness of policymakers to expand access to educational opportunities and provide quality education may translate into higher per-pupil costs and must be balanced against other public spending requirements and overall tax burdens. Although it is difficult to determine the level of spending and resources that each student needs to prepare for work and life in modern societies, international comparisons of spending on educational institutions can be used as useful reference points. Per-student spending in educational institutions is influenced by the cost of instructional materials and facilities, the number of students enrolled in the education system, teachers' salaries, pension systems, and the programs offered (e.g., general education or vocational). In addition, policies to reduce average class sizes, attract talented teachers, or change staffing structures also affected per-pupil spending. In general, education expenditures at the primary and secondary school levels dominate spending on education services. They include operating costs for energy, water and maintenance. Here, of course, we are only concerned with the school level, so we have not included teachers' salaries, for example, because this is the responsibility of the government at all levels of education, not just at the school level.

2. **Impact on Local Economic**

The employment rate is one of the most meaningful indicators of economic growth. Each month, job creation numbers are used as a measure of how much a country's economy is growing or shrinking. Indeed, schools employ an enormous number of teachers, administrators and support staff. Therefore, it is important to develop an indicator that, on the one hand, identifies the contribution of schools to the creation of jobs in society and helps to reduce the unemployment rate. On the other hand, this indicator is closely related to the social indicators, because job creation still depends on the development of students' skills and knowledge to equip them for the labor market.

The importance of production activities in schools is the possibility of using school facilities after classes. Nationally, there are many attempts to use school facilities for childcare, vocational training, and vocational training centers. This helps students learn about economic growth and productivity in a meaningful way and strengthens the role of schools in serving society and individuals effectively and beneficially.

4.5.5 Comparison between the Palestinian School's Framework and International Frameworks

Comparing our proposed framework for assessing school sustainability in Palestine with existing frameworks such as LEED for Schools, BREEAM Education, SBTool for K-12 Schools, and the Palestinian Green Building Guidelines, as shown in Figure 4.1 (or Table 4.5 in Appendix 4), several important points can be discussed:

1. The proposed Palestinian framework covers a comprehensive range of environmental aspects consistent with other frameworks. It includes indicators such as energy efficiency and incorporates heating, cooling and lighting consumption, as well as the building envelope. It also emphasizes the promotion of renewable energy generation and efficient water management, taking into account both total water consumption and water supply consumption. Waste management is also an important aspect, ensuring proper handling and disposal of waste on school grounds. By examining these categories and indicators, the Palestinian framework, like other frameworks, demonstrates a comprehensive approach to environmental sustainability.
2. Unlike some existing frameworks, the proposed framework has a clear focus on social aspects, such as SBTool. It includes indicators for social equity, social inclusion, human-centered design, occupant health, ergonomic comfort, and social interaction. By including these dimensions, the proposed framework recognizes the importance of fostering a supportive and inclusive school environment that addresses the diverse needs of students and supports their well-being. This focus on social aspects is consistent with the overarching goal of holistic sustainability. However, it is important to note that other frameworks also include some social indicators, such as accessibility. The difficulty is that they are not clearly placed in a separate and systematic category.
3. Teaching quality is another crucial aspect of the proposed Palestinian framework. By looking at indicators such as pass rates, attendance rates, disciplinary referrals, and dropout rates, the framework emphasizes the critical role of educational outcomes in

assessing sustainability. Sustainability in schools encompasses not only infrastructure, but also educational effectiveness and student achievement. This section can be seen as a step toward filling the fourth gap described in Section 4.4.2, which is the development of frameworks to measure the impact of sustainability on students' social and school lives.

4. Economic aspects are integrated in the proposed framework, as in the other frameworks, through the assessment of annual operating costs. Another important idea is the contribution to local economic development. Thus, the Palestinian framework addresses the practical aspect of sustainability. Moreover, the proposed framework shows compatibility and synergy with the Palestinian Green Building Guidelines, complementing and extending them. This alignment ensures consistency with the national sustainability goals and increases the relevance of the framework in the Palestinian context.

In summary, the proposed framework for school sustainability assessment in Palestine is characterized by its holistic coverage of environmental, social, and economic aspects. This framework is compatible with existing international tools that consider the specific needs and challenges of schools in Palestine, thus promoting sustainable development in the education sector.

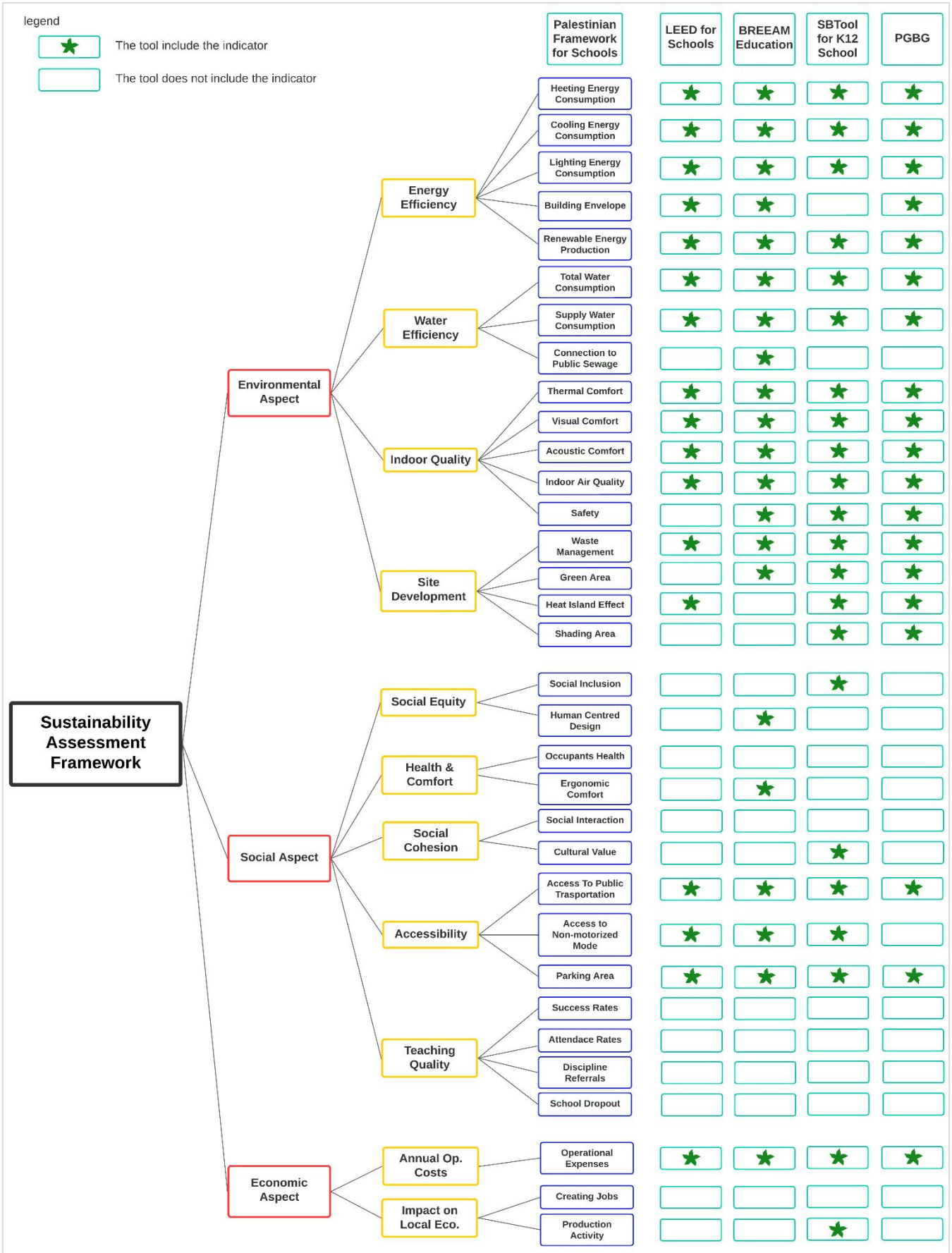

Figure 4.1. Comparison between the Palestinian school's framework and international frameworks.

4.5School's Indicators Weights

This section presents the results obtained through a process that included expert opinions and the application of SWARA and AHP methods. These methods allow for a systematic analysis of the relative importance of different sustainability categories and indicators. By combining expert knowledge and quantitative analysis, we can create a robust framework that effectively supports sustainability assessments and decision-making processes.

4.6.1 Experts' Profile and General Opinions

The questionnaire was conducted by experts to determine the importance of each assessment indicator and its applicability to the Palestinian local context, as described in Chapter 3. Table 4.14 summarizes the profile of twenty-eight (28) expert respondents. About 64% of them have a Ph.D. They cover majors such as architecture, civil engineering, energy, electrical engineering, and economics. About 50% of the experts are architects. About half of the experts work in the public sector and the other half in the private sector. Furthermore, 86% of the experts have more than 10 years of experience in sustainability and schools.

Table 4.14. The experts' personal information.

Experts' Personal Information			
Classification			**No.**
1	**Gender**	Male	23
		Female	5
2	**Education level**	Bachelor	6
		Master	4
		PhD	18
3	**Specialization**	Architecture	14
		Civil Engineering	5
		Economic	1
		Energy Engineering	7
		Electrical & Telecom Engineering	1
4	**Working Sector**	Public Sector	12
		Privet Sector	16
5	**Experience**	3–10 years of experience	4
		More than 10 years of experience	24

28 Palestinian experts evaluated the set of indicators established. The results are presented in Table 4.15 as a heat map. The heat map indicates that approximately 86% of the experts rated the set of indicators highly (score of 4 or 5), while only 12% provided an intermediate score of 3. This result shows the importance, comprehensiveness, and relevance of indicators for assessing sustainability in Palestinian schools, according to the experts' opinion. The global score ranged from 108 (Heat Island Effect) to 135 (Social Inclusion), with an average value of 120 and a standard deviation of 7.

Table 4.15. Heat-map results to each category and indicator based on respondents.

Aspect	Category	Indicator	ID	Scale for Quantitative parameters					Global Score
				1 to 5 (1 Less important, 5 More important)					
				1	2	3	4	5	
Environmental Aspect	Energy Use Efficiency	Heating Energy Consumption	P1	0	1	1	10	16	125
		Cooling Energy Consumption	P2	0	2	3	11	12	117
		Lighting Energy Consumption	P3	0	4	3	11	10	111
		Building Envelope Insulation	P4	0	1	1	8	18	127
		Renewable Energy Production	P5	0	0	6	6	16	122
	Water Use Efficiency	Total Water Consumption	P6	0	0	0	12	16	128
		Water Harvesting and Greywater Recycling	P7	0	0	7	11	10	115
		Connection to Public Sewage	P8	0	2	7	8	11	112
	Indoor Quality	Thermal Comfort	P9	0	0	2	10	16	126
		Visual Comfort	P10	0	0	3	12	13	122
		Acoustic Comfort	P11	0	1	3	11	13	120
		Indoor Air Quality	P12	0	0	1	5	22	133
		Safety and Security	P13	0	1	1	8	18	127
	Site Development	Waste Management Strategies	P14	0	1	0	20	7	117
		Green Areas	P15	0	0	3	9	16	125
		Heat Island Effect	P16	0	1	7	15	5	108
		Shading Area	P17	0	0	3	15	10	119
Social Aspect	Social Equity	Social Inclusion	P18	0	0	1	3	24	135
		Human Centred Design	P19	0	0	2	18	8	118
	Health and Comfort	Occupants Health	P20	0	0	0	7	21	133
		Ergonomic Comfort	P21	0	1	3	12	12	119
	Social Cohesion	Social Interaction	P22	0	0	2	15	11	121
		Cultural Value	P23	0	0	3	11	14	123
	Accessibility	Access to Public Transportation	P24	0	0	1	12	15	126
		Access to Non-motorized mode of movement	P25	0	0	4	11	13	121
		Parking Area	P26	0	2	1	15	10	117
	Teaching Quality	Success Rate	P27	0	0	4	16	8	116
		Attendance Rate	P28	0	0	4	14	10	118
		School Dropout	P29	0	2	7	11	8	109
		Discipline Referrals	P30	0	3	6	10	9	109
Economic Aspect	Annual Operating Costs	Operational Energy Expenses	P31	0	1	5	13	9	114
		Operational Water Expenses	P32	0	1	5	15	7	112
		Maintenance Cost	P33	0	0	4	15	9	117
	Influence on Local Economy	Creating Jobs/ Employment	P34	0	0	6	9	13	119
		Social Activity	P35	0	2	7	10	9	110

4.6.2 Weights of Schools' Categories

Table 4.16 shows the SWARA weights and the corresponding category rankings, while Table 4.17 shows the AHP matrix and category weights. The consistency ratio (CR) for this matrix is 5.90, which is less than 10%. It is noticeable that the ranking of the categories is consistent between the two methods, although the weights are slightly different but relatively close. "Social Justice" received the highest weighting, while "Quality of Teaching" received the lowest weighting.

Table 4.16. Ranks of the sustainability categories according to the experts' opinion by using SWARA method.

Sustainability Categories	Global Score	Rank	Comparative importance of average value (sj)	Coefficient (Kj)	Recalculated weight (qj)	Weight (Wj)
Social Equity	127	1		1	1	**0.0974**
Indoor Quality	126	2	0.01	1.01	0.99	**0.0964**
Health and Comfort	126	3	0	1	0.99	**0.0964**
Social Cohesion	122	4	0.04	1.04	0.95	**0.0927**
Accessibility	121	5	0.01	1.01	0.94	**0.0918**
Energy Use Efficiency	120	6	0.01	1.01	0.93	**0.0909**
Water Use Efficiency	118	7	0.02	1.02	0.91	**0.0891**
Site Development	117	8	0.01	1.01	0.91	**0.0882**
Influence on Local Economy	115	9	0.02	1.02	0.89	**0.0865**
Annual Operating Costs	114	10	0.01	1.01	0.88	**0.0856**
Teaching Quality	113	11	0.01	1.01	0.87	**0.0848**

Table 4.17. The AHP matrix and the weights of the sustainability categories according to the experts' opinion.

Sustainability Categories	ID	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	Weight
Social Equity	C1	1.00	1.01	1.01	1.04	1.05	1.06	1.08	1.09	1.10	1.11	1.12	**0.0963**
Indoor Quality	C2	0.99	1.00	1.00	1.03	1.04	1.05	1.07	1.08	1.10	1.11	1.12	**0.0955**
Health and Comfort	C3	0.99	1.00	1.00	1.03	1.04	1.05	1.07	1.08	1.10	1.11	1.12	**0.0955**
Social Cohesion	C4	0.96	0.97	0.97	1.00	1.01	1.02	1.03	1.04	1.06	1.07	1.08	**0.0925**
Accessibility	C5	0.95	0.96	0.96	0.99	1.00	1.01	1.03	1.03	1.05	1.06	1.07	**0.0917**
Energy Use Efficiency	C6	0.94	0.95	0.95	0.98	0.99	1.00	1.02	1.03	1.04	1.05	1.06	**0.0910**
Water Use	C7	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.04	**0.0895**

Efficiency		3	4	4	7	8	8	0	1	3	4		
Site Development	C8	0.92	0.93	0.93	0.96	0.97	0.98	0.99	1.00	1.02	1.03	1.04	**0.0887**
Influence on Local Economy	C9	0.91	0.91	0.91	0.94	0.95	0.96	0.97	0.98	1.00	1.01	1.02	**0.0872**
Annual O. Costs	C10	0.90	0.90	0.90	0.93	0.94	0.95	0.97	0.97	0.99	1.00	1.01	**0.0864**
Teaching Quality	C11	0.89	0.90	0.90	0.93	0.93	0.94	0.96	0.97	0.98	0.99	1.00	**0.0857**

The experts gave the greatest importance to the categories that fall under the social aspect and to the social aspect in general. Table 4.18 shows the weighting of the aspects based on the experts' opinion, which shows that the experts' interest is focused on promoting social indicators in school. This is in line with the goals of education and schools in Palestine. The strategic plan of the Palestinian Ministry of Education (2021-2023) highlights the importance of safe, inclusive and equitable access to education as the first goal. The second goal is to improve the quality of education by improving educational outcomes, strengthening inputs and processes, evaluating outcomes, and establishing mechanisms to measure progress (Ministry of Education, 2021).

Table 4.18. The weights of the sustainability aspects according to the experts' opinion.

Sustainability Aspect	Weight
Social	46.2 %
Environmental	36.5 %
Economic	17.4 %

The importance of the environmental aspect of the school can be observed in second place in terms of energy and water consumption, the quality of the internal environment and the sustainability of the site. Table 4.7 shows the weighting of the sustainability categories in the Palestinian Green Building Guideline (PGBG), and they agree with the experts' opinion regarding the importance of energy and water efficiency. However, the experts give higher importance to indoor quality than in the PGBG. This difference can be attributed to the crucial role of indoor quality in educational buildings, as it directly affects the health of students, who may suffer from various symptoms due to an unhealthy indoor environment. In addition, it is worth noting that the PGBG does not consider the social and economic categories. Table 4.19 provides descriptive statistics on the weights. The descriptive statistics provide an overview of the distribution and characteristics of the weights obtained by the SWARA and AHP methods. The mean weight for both methods is 0.0909, indicating relatively similar mean importance for the categories. The mean values are very close to the mean values of both methods, indicating a relatively symmetrical distribution. The SWARA method has a mean weight of 0.0909, while the AHP method has a slightly higher mean weight of 0.0910. The mode values refer to the most common weighting values. For the SWARA method, the mode is 0.0964, while for the AHP method it is 0.0955. This indicates that there may be a peak or range of weights around these values in the respective distributions.

The SWARA method has a standard deviation of 0.0045, while the AHP method has a slightly lower standard deviation of 0.0038. These values show that the weights are relatively close to the mean for both methods. The descriptive statistics also include measures of kurtosis and skewness, which indicate the shape of the weight distribution. Negative values of kurtosis and skewness indicate a slightly flattened and less skewed distribution. The range of values shows how different the weights are. The SWARA method has a range of 0.0126, while the AHP method has a slightly smaller range of 0.0106. In short, the distributions appear to be about the same, with no outliers or runaways.

Table 4.19. The descriptive statistics for the SWARA and AHP categories' weights.

Descriptive Statistics	SWARA Method	AHP Method
Mean	0.0909	0.0909
Standard Error	0.0014	0.0011
Median	0.0909	0.0910
Mode	0.0964	0.0955
Standard Deviation	0.0045	0.0038
Sample Variance	0.0000	0.0000
Kurtosis	-1.3617	-1.3659
Skewness	0.1793	0.1308
Range	0.0126	0.0106
Minimum	0.0848	0.0857
Maximum	0.0974	0.0963

4.6.3 Weights of Schools' Indicators

After applying the SWARA and AHP methods to the indicator scores, the ranking and weighting of the indicators are presented in Table 4.20. It can be seen that the most important indicator is "Social Inclusion"." This indicator assesses a public school's ability to accommodate low-income students with disabilities. It highlights the critical role of the school in promoting social equity, one of the most important goals in pursuing sustainable education. It is followed by the indicators "indoor air quality" and "occupant health" with equal scores. As has been made clear, a healthy indoor environment for students is one of the most important sustainability principles.

Table 4.20. The weights of indicators by utilizing SWARA and AHP methods.

Indicator	ID	Rank	Indicator Weight (SWARA)	Indicator Weight (AHP)
Social Inclusion	P18	1	0.0331	0.0322
Indoor Air Quality	P12	2	0.0325	0.0317
Occupants Health	P20	3	0.0325	0.0317
Total Water Consumption	P06	4	0.0309	0.0305
Building Envelope Insulation	P04	5	0.0306	0.0303
Safety and Security	P13	6	0.0306	0.0303
Thermal Comfort	P09	7	0.0303	0.0301
Access to Public Transportation	P24	8	0.0303	0.0301

Heating Energy Consumption	P01	9	0.0300	0.0298
Green Areas	P15	10	0.0300	0.0298
Cultural Value	P23	11	0.0294	0.0293
Renewable Energy Production	P05	12	0.0292	0.0291
Visual Comfort	P10	13	0.0292	0.0291
Social Interaction	P22	14	0.0289	0.0289
Access to Non-motorized mode of movement	P25	15	0.0289	0.0289
Acoustic Comfort	P11	16	0.0286	0.0286
Shading Area	P17	17	0.0283	0.0284
Ergonomic Comfort	P21	18	0.0283	0.0284
Creating Jobs/Employment	P35	19	0.0283	0.0284
Human centred Design	P19	20	0.0280	0.0282
Attendance Rate	P28	21	0.0280	0.0282
Cooling Energy Consumption	P02	22	0.0277	0.0279
Waste Management Strategies	P14	23	0.0277	0.0279
Parking Area	P26	24	0.0277	0.0279
Maintenance Cost	P33	25	0.0277	0.0279
Success Rate	P27	26	0.0275	0.0277
Water Harvesting and Greywater Recycling	P07	27	0.0272	0.0274
Operational Energy Expenses	P31	28	0.0269	0.0272
Connection to Public Sewage	P08	29	0.0264	0.0267
Operational Water Expenses	P32	30	0.0264	0.0267
Lighting Energy Consumption	P03	31	0.0261	0.0265
Social Activity	P36	32	0.0259	0.0262
School Dropout	P29	33	0.0256	0.0260
Discipline Referrals	P30	34	0.0256	0.0260
Heat Island Effect	P16	35	0.0254	0.0258

The respective descriptive statistics of the indicator weights obtained by the SWARA and AHP methods are shown in Table 4.21. The mean weight for the SWARA and AHP methods is 0.0286, indicating similar average importance of the indicators. The standard error values for both methods are 0.0003, indicating that the variability in the mean weighting estimates is relatively small. The median values are 0.0283 for the SWARA method and 0.0284 for the AHP method. These values are very close to the respective means, indicating a symmetrical distribution with no significant outliers. The mode values indicating the most common weighting values are 0.0277 for the SWARA method and 0.0279 for the AHP method. These values indicate that there may be a peak or clustering of weights around these values in the respective distributions.

In addition, the standard deviation values, which represent the dispersion of the weight distribution, are 0.0020 for the SWARA method and 0.0017 for the AHP method. These values show that the weights are relatively close to the mean for both methods. The values for the range are 0.0078 for the SWARA method and 0.0064 for the AHP method. These values reflect the amount of variation in weights. The minimum and maximum values indicate the lowest and highest weights, respectively. The minimum weighting is 0.0254 for the SWARA

method and 0.0258 for the AHP method and both for the "heat island effect." The maximum weight is 0.0331 in SWARA method and 0.0322 in AHP method and both for "social justice". In general, descriptive statistics provide a clear summary of the central tendency, variance and distribution of the data. This confirms that all indicators are important and comprehensive and that none of them can be dispensed with.

Table 4.21. The descriptive statistics for the SWARA and AHP indicators' weights.

Descriptive Statistics	SWARA Method	AHP Method
Mean	0.0286	0.0286
Standard Error	0.0003	0.0003
Median	0.0283	0.0284
Mode	0.0277	0.0279
Standard Deviation	0.0020	0.0017
Sample Variance	0.0000	0.0000
Kurtosis	-0.2675	-0.4092
Skewness	0.4395	0.2972
Range	0.0078	0.0064
Minimum	0.0254	0.0258
Maximum	0.0331	0.0322

We note that the weighting of the indicators is consistent with the concepts of sustainability and the context of the schools in Palestine. For example, "insulation of the building envelope" and "shading of the exterior facades" are of greater importance than "renewable energy generation", since energy conservation is better than the generation of the alternative. Similarly, "energy use for cooling" is considered less important than "energy use for heating" because schools are generally not in operation during the summer. The same logic applies to the "heat island effect" indicator.

Experts attach great importance to indoor environment quality. It is noteworthy that the indicators related to indoor quality occupy a place in the upper half of the priority list. For example, the indicator "indoor air quality" ranks second across all criteria. It is followed by "Safety," "Thermal Comfort"," "Visual Comfort"," and finally "Acoustic Comfort"," which ranks 16th out of a total of 35 indicators. This underscores the importance of indoor quality for both students and school staff and highlights the profound impact these indicators have on health and educational outcomes. Consequently, they play a critical role in shaping the future of the nation and the next generation.

Expert opinion attaches great importance to "access to public transportation" as it is critical that public school buildings are easily accessible through such services. In general, social indicators have a higher value than environmental and economic indicators, such as "Cultural value", "Social interaction", "Access to non-motorized transportation", "Ergonomic comfort" and "People-centered design". Regarding the economic aspect, the weighting of "job creation" is higher than that of the indicators on "operation and maintenance costs". This underlines the importance of schools as active and productive institutions in society.

4.6.4 The Indicators Scores according to Experts' Specialization

Most of the responses in the survey were from architects, civil engineers, and energy and renewable energy engineers. Table 4.22 shows the indicator scores categorized by the experts' specialization. Architects rated the three pillars of sustainability with almost equal proportions and equal importance. This consistency in scoring is significant and has implications for the evaluation process. One possible reason for this trend is that in Palestine architects play an important role in monitoring sustainability projects. The average scores for the environmental, social, and economic categories were 4.36, 4.37, and 4.43, respectively.

Civil engineers showed a clear preference for the environmental category over the social and economic categories, which is an apparent inconsistency. It is noteworthy that the average rating of the environmental category is 4.38, which is also the highest rating among the three disciplines. In contrast, the average rating of the social group was 4.06, while the average rating of the economic group was relatively low at 3.70. This discrepancy can be attributed to the nature of the work of civil engineers, who focus primarily on the physical aspects of buildings rather than other dimensions. They focused heavily on factors such as energy consumption, water use, and indoor environmental quality, and rated them with an average of 4.8, indicating a high level of importance. Social indicators, on the other hand, were rated at an average of 4, indicating a medium level of importance. The economic indicators were rated at an average of 3.6, indicating a rating between neutral and important.

The rating of energy engineers was similar to that of architects. The average for the environmental, social, and economic categories was 4.11, 4.18, and 3.96, respectively. The social category received the highest rating due to its importance to the education system.

Table 4.22. The score of indicators based on the specialization of experts.

Specialization	Architect	Civil Engineer	Energy Engineer	Specialization	Architect	Civil Engineer	Energy Engineer
Environmental Aspect				Social Aspect			
Heating Energy Consumption	4.43	4.60	4.29	Social Inclusion	4.79	4.80	4.86
Cooling Energy Consumption	4.29	3.80	4.00	Human Centred Design	4.29	4.00	4.29
Lighting Energy Consumption	3.93	4.20	4.14	Occupants Health	4.71	5.00	4.71
Building Insulation	4.64	4.80	4.14	Ergonomic Comfort	4.36	4.00	4.29
Renewable Energy	4.43	4.00	4.29	Social Interaction	4.43	4.00	4.29
Total Water Consumption	4.43	4.80	4.57	Cultural Value	4.36	4.00	4.57
Water Harvesting and Greywater Recycling	4.43	3.60	3.57	Social Activity	3.93	3.60	3.86
Connection to Public Sewage	3.93	4.00	4.00	Access to Public Transportation	4.64	4.00	4.43
Thermal Comfort	4.57	4.80	4.29	Access to Non-	4.71	3.60	4.14

				motorized			
Visual Comfort	4.21	4.80	4.29	Parking Area	4.29	3.80	4.43
Acoustic Comfort	4.29	4.80	4.00	Success Rate	4.29	3.80	4.14
Indoor Air Quality	4.79	5.00	4.43	Attendance Rate	4.57	4.00	3.71
Safety and Security	4.50	4.80	4.29	School Dropout	3.93	4.00	3.57
Waste Management	4.14	4.20	4.14	Discipline Referrals	3.93	4.20	3.29
Green Areas	4.64	4.40	4.00	Avg. Social	4.37	4.06	4.18
Heat Island Effect	4.07	3.60	3.71	Economic Aspect			
Shading Area	4.43	4.20	3.71	Operational Energy Expenses	4.43	3.60	4.00
Avg. Environmental	4.36	4.38	4.11	Operational Water Expenses	4.29	3.60	4.00
				Maintenance Cost	4.57	3.80	3.86
				Creating Jobs/ Employment	4.43	3.80	4.00
				Avg. Economic	4.43	3.70	3.96

4.7 Conclusion

This chapter presented a comprehensive framework for assessing the sustainability of existing public buildings in Palestine. The framework provides guidance to authorities for setting standards for sustainable construction and assessing the sustainability performance of existing public buildings. It was developed through the review of international standards, adaptation to the Palestinian context, and expert opinion. The framework includes 25 indicators covering six categories of sustainability: energy efficiency, water efficiency, green city, indoor environmental quality, social aspects, and economic aspects. The expert opinions underlined the importance of energy efficiency and indoor environmental quality as main aspects in public buildings. In addition, energy consumption and renewable energy generation were mentioned as important factors in the energy efficiency category, while water consumption appeared in the water efficiency category. The importance of green spaces, waste management, thermal comfort, indoor air quality and security were highlighted in the different categories.

The Palestinian Schools Assessment Framework is an important outcome of this research. By applying this framework, teachers and students gain a comprehensive understanding of the role of education in promoting sustainability. In addition, the implementation of this framework at the system level promotes change in educational policies, visions, teaching methods, learning environments, and practices. The framework includes 35 indicators covering 11 sustainability categories: energy efficiency, water efficiency, indoor quality, site development, social equity, health and comfort, social cohesion, accessibility, instructional quality, impact on local economies, and annual operating costs. According to experts, social equity and indoor space quality are more important in public schools, while the economic dimension is less important.

The proposed framework for assessing the sustainability of schools in Palestine is an important step in promoting sustainability in the education sector. Because this framework emphasizes the social dimension, unlike many global frameworks, it provides a more comprehensive and accurate assessment of schools. Expert comments emphasized the importance of social indicators, specifically highlighting “social inclusion” as a critical factor in meeting the needs of marginalized students. The framework also focuses on “indoor air quality,” “population health,” and other social elements that contribute to a conducive learning environment.

Going forward, there is a need to further strengthen the framework by expanding collaboration with civil society representatives and experts from the social and economic sectors. This broader involvement will ensure a more comprehensive and inclusive assessment that incorporates diverse perspectives and experiences. In this way, the framework will be continually reviewed and adapted to meet the changing needs and challenges of schools in Palestine. In the next chapter, this framework will be used to assess the sustainability of some schools in Palestine and identify strengths and areas for improvement in these schools.

Chapter 5 Analysis of the Sustainability of Palestinian Schools

5.1 Introduction

Based on the explanation of the case study and the sustainability assessment framework used, this chapter serves as a focal point in examining the sustainability of Palestinian schools. The chapter uses the Comprehensive Sustainability Index as an effective analytical tool to assess the sustainability performance of these educational institutions. The following sections thoroughly analyze and understand the complex web of sustainability indicators, revealing important elements of current educational practices.

The sustainability indicators of the participating schools are analyzed in detail in Section 5.2. This systematic approach reveals important insights into the current environment of sustainable practice, which encompasses a range of characteristics. To further explore the nuances, we turn to Section 5.3, where we provide a broad overview of the sustainability index values along with descriptive statistics, ideal and worst-case scenarios, and special cases. These findings highlight the need for substantial improvements by comprehensively expanding our understanding of the sustainability models currently used in Palestinian schools.

In addition, Section 5.4 uses the invaluable resource of "student opinion" to assess indoor environmental quality, which includes thermal, visual, and acoustic comfort, safety, and ergonomic comfort of furniture and colors. This student-centered aspect underscores the importance of their participation in the assessments and is consistent with the shared vision of enhancing well-being, increasing comfort, and ultimately improving the educational environment.

Comprehensive analysis and interpretation of the data collected will lead to a deeper understanding of the sustainability performance of Palestinian schools. This important information provides policy makers, educators, and stakeholders with insights that enable them to develop successful interventions that raise the banner of sustainability across the educational landscape.

5.2 Analysis of Sustainability Indicators

This section analyses the collected data according to indicators presented earlier.

5.2.1 Overview of Collected Data

Data were collected from 40 schools from Tulkarm and 14 schools from Nablus, including 37 elementary school and 17 secondary schools. Secondary schools included 9 scientific secondary schools, 13 literary secondary schools, one industrial school, and 4 schools focused on entrepreneurship and business. By gender, there were 26 schools for girls, 19 schools for boys, and 9 schools for both genders at the primary level. In addition, schools from different geographic areas were included in the data collection: Villages (13), cities (6),

and large towns (35). In terms of year of establishment, the selected schools showed a wide range, with the oldest school established in 1908 and the youngest in 2020.

The average building area is 1,395 m^2 and the median is 1,002 m^2, while the mode value is 1200, indicating the most frequent occurrence of this value in the dataset. The range value is 7,395, illustrating significant variability in school building square footage in the selected group. This range results in varying student population densities, ranging from 0.07 to 1.82 student/m^2, with an average of 0.42 student/m^2. It is worth noting that the design standards approved by the General Administration of Buildings of the Ministry of Education prescribe a ratio of not less than 0.80 students/m2 (1.2 m^2/student). However, these criteria do not take into account the specific population density of the chosen area, school level (primary or secondary), gender segregation, or location (urban or rural) at the planning stage. As a result, some schools may have lower student densities than others because the planning standards do not take these factors into account. All of these data are presented in Table 5.1 in Appendix 5.

5.2.2 Descriptive Statistics for Schools' Indicators

This part aims at a comprehensive analysis of each indicator of the responding schools. The analysis will provide a detailed description of the results obtained and use descriptive analysis techniques to evaluate schools based on the indicators selected in our framework.

1. **Environmental Indicators**

Energy Indicators

Within the environmental category, we first focus on energy-related issues, including energy consumption and generation, and the use of insulation and shading for exterior walls, as shown in Table 5.2 in Appendix 5. Figure 5.1 shows the variation of energy consumption with construction date. The energy consumption varies from 1.86 to 38.32 kWh/m^2, with an average consumption of 10.17 kWh/m^2. We observe a low correlation (correlation coefficient = -0.13) between the energy consumption and the construction date, with a weak tendency for the energy consumption to decrease with the construction date. The consumption of about 62% is below the average value, while the consumption of only 5 schools exceeds 20 kWh/m^2. The data of these schools do not provide justification for this high consumption in relation to other schools: (i) some schools are old (construction in 1954 and 1956), others are more recent, (ii) almost all schools are not insulated, (iii) all schools have no shading.

10 schools are equipped with solar panels with a production capacity of 5 and 50 kW, with an average value of 14.2 KW. The average energy consumption of these buildings is 8.83 kWh/m^2, indicating a higher energy performance in relation to the whole of the schools. Only 10 schools are insulated, which represents 19% of the sample. Their consumption varies between 1.86 and 14.68 kWh/m^2, with an average of 6.84 kWh/m^2, which is lower than the average consumption of all schools. This result indicates a positive effect of insulation on the reduction of energy consumption. About 15 schools are equipped with shading. Their consumption varies from 3.49 to 18.56 kWh/m^2, with the average (8.61 kWh/m^2) indicating a moderately positive effect of shading on reducing energy consumption. Figure 5.2 shows these values compared to the energy consumption of the schools as a whole.

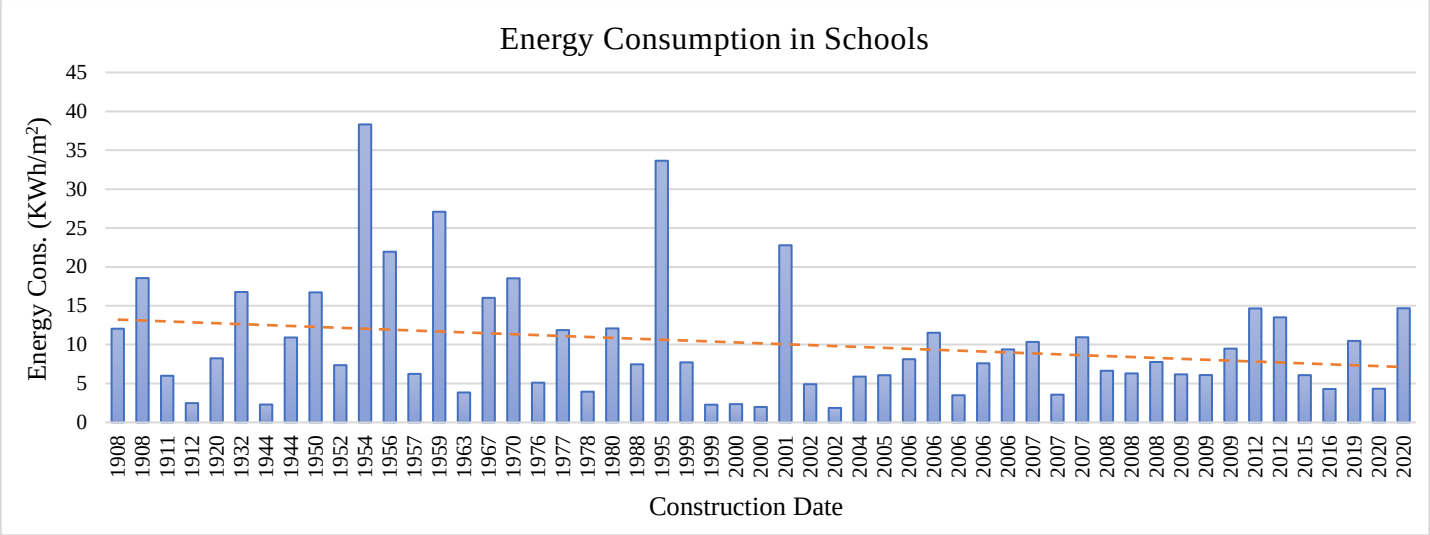

Figure 5.1. Energy consumption in schools with the construction date.

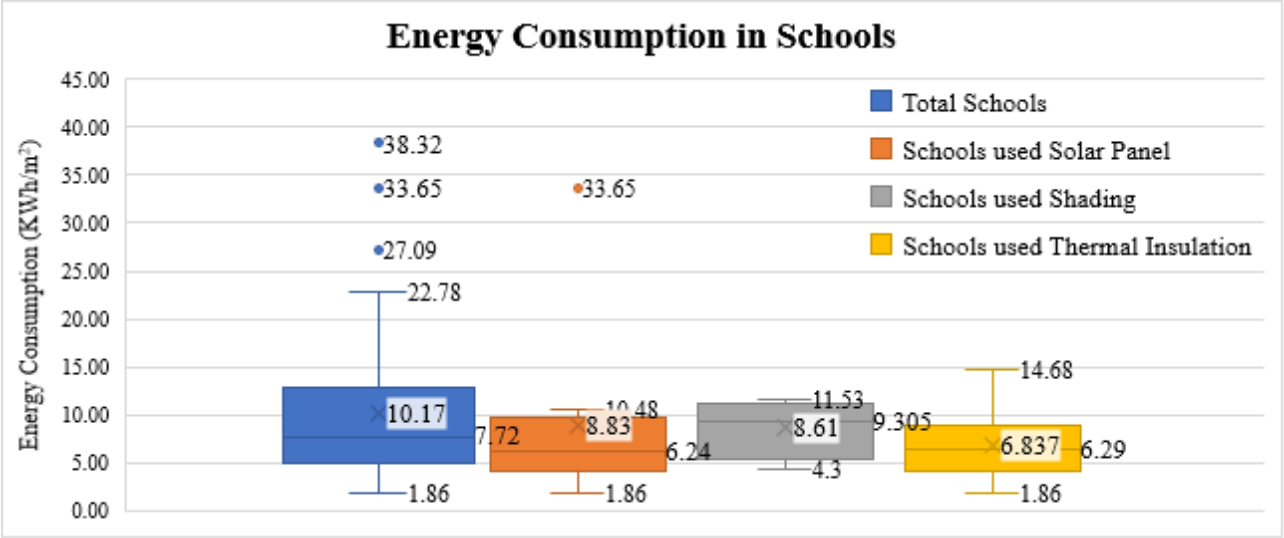

Figure 5.2. The energy consumption in all schools comparing with schools used solar panel, thermal insulation, and shading.

Despite the positive correlation between energy consumption and thermal insulation or shading shown in Figure 5.2, it is important to note that Palestinian schools do not use heating or cooling systems. The absence of heating or cooling systems means that energy consumption is mainly focused on lighting and other equipment such as computers. Consequently, the presence or absence of insulation and shading methods does not have a significant impact on energy consumption in these schools. Instead, the main focus is on promoting student comfort and well-being in the school environment.

Figure 5.3 compares the energy consumption of elementary and secondary schools to the total energy consumption of all schools. Secondary schools have lower consumption (7.41 KWh/m2) than elementary school (11.47 KWh/m^2) with a percentage of 55%. This discrepancy is to be expected, since secondary school students are more aware of the importance of energy conservation and the need for its rational use. The energy consumption in the schools for boys was reported as 10.28 KWh/m^2, while the schools for girls had an average consumption of 10.60 KWh/m^2, as shown in Figure 5.4. This is related to factors

such as differences in user behavior between boys' and girls' schools, the nature of educational activities and programs, and differences in operating practices, maintenance procedures, and energy management strategies. Figure 5.5 shows the regional differences. The average energy consumption in schools in Tulkarm is 9.48 kWh/m^2, while schools in Nablus have a higher value of 12.08 kWh/m^2 with a percentage of 27%. One possible reason for this difference is weather conditions. In Tulkarm, the weather is warmer and sunnier most of the year, so energy consumption can be reduced by turning off lighting systems and heaters when they are not needed. This contributes to the general decrease in energy consumption in the Tulkarm area.

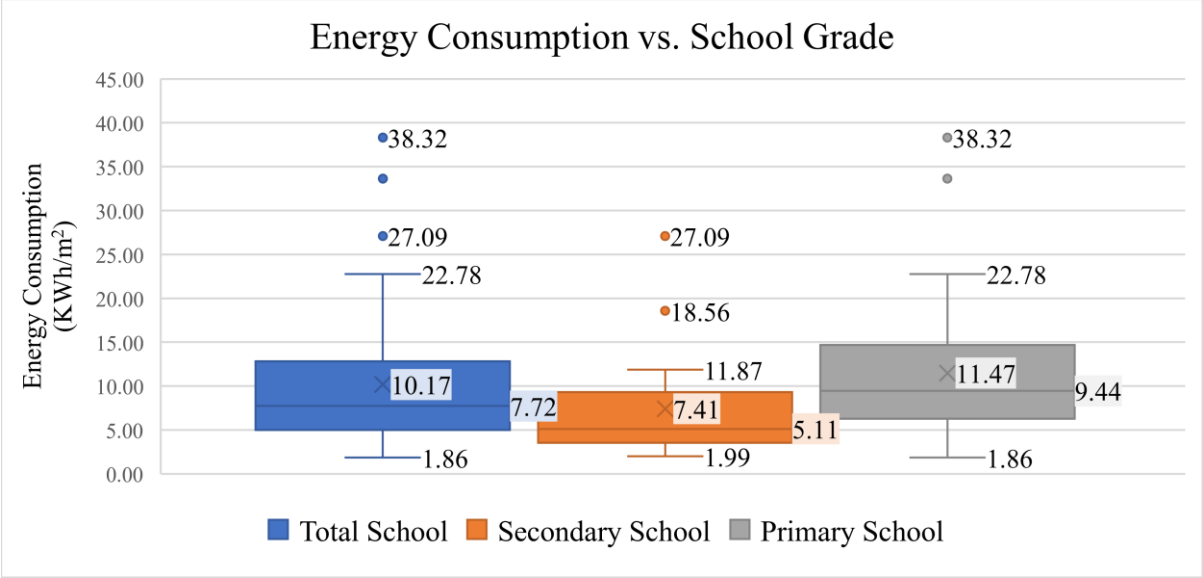

Figure 5.3. The energy consumption in all schools comparing with secondary and primary schools.

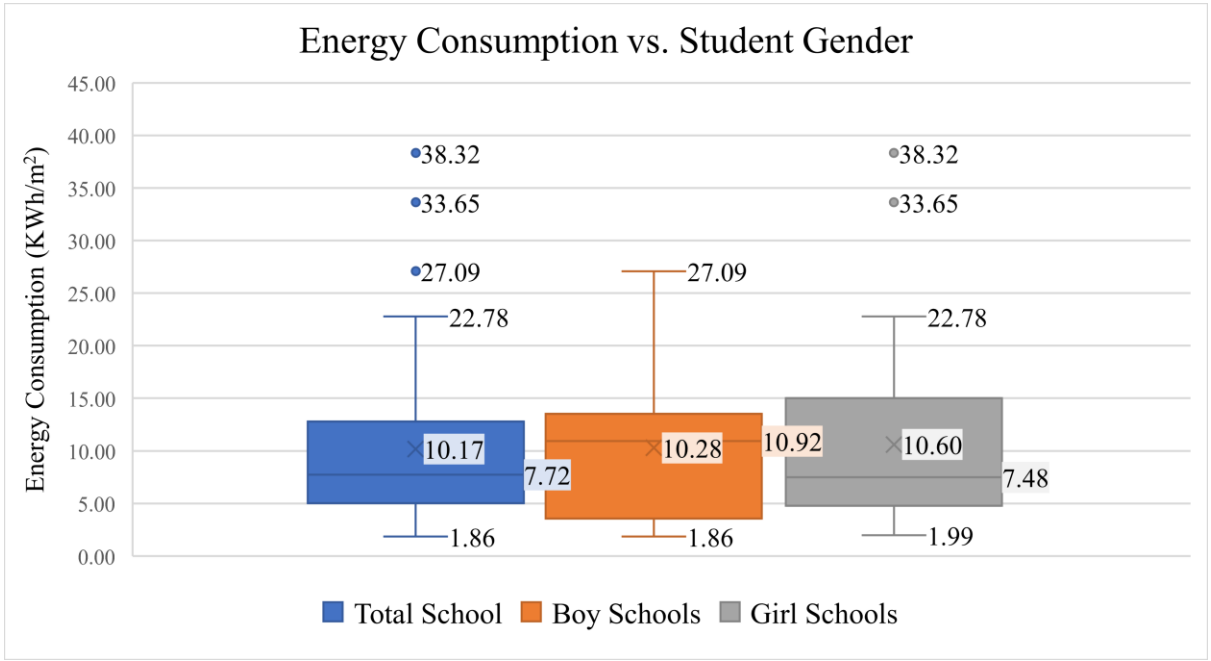

Figure 5.4. The energy consumption in all schools comparing with boy and girl schools.

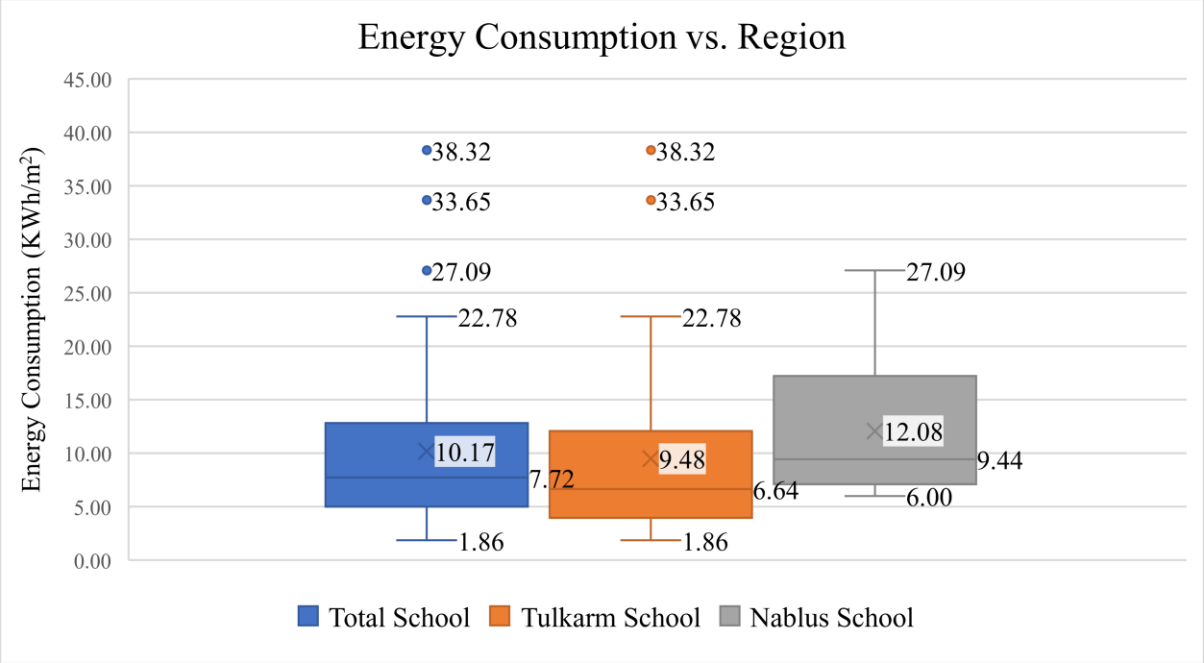

Figure 5.5. The energy consumption in all schools comparing with Tulkarm and Nablus schools.

Water and Sanitation

Moving on to the issue of water and sanitation from an environmental perspective, as shown in Table 5.3 in Appendix 5. The average water consumption is 1818 l/student.yr, with a maximum of 9667 l/student.yr and a minimum of 365 l/student.yr. Figure 5.6 shows a low correlation (correlation coefficient = 0.08) between water consumption and construction date, but there is a weak tendency for water consumption to increase with construction date. Approximately 72% of the data points are below the mean, while 28% of the data points exceed it. This indicates an asymmetric distribution tending toward lower values. This distribution pattern indicates that most of the observations have values below the mean value.

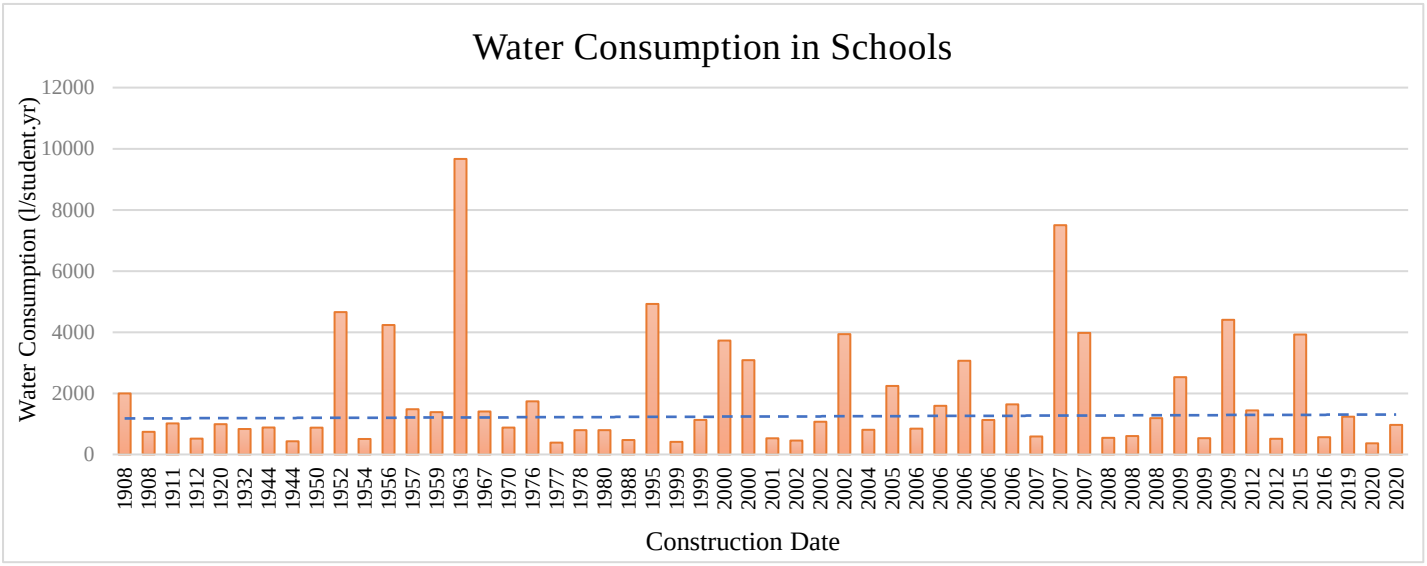

Figure 5.6. Water consumption in schools with the construction date.

Only 8 schools, or 15%, implemented rainwater harvesting tanks. These tanks are usually used for irrigation and flushing purposes. Figure 5.7 presents the water consumption in these schools. It shows that schools with rainwater tanks use less water (with avg. 1121 l/student.yr) than other schools by 62%. This percentage illustrates the importance of raising awareness of water conservation and encouraging the implementation of rainwater harvesting systems as critical steps in addressing the issue of water consumption in schools.

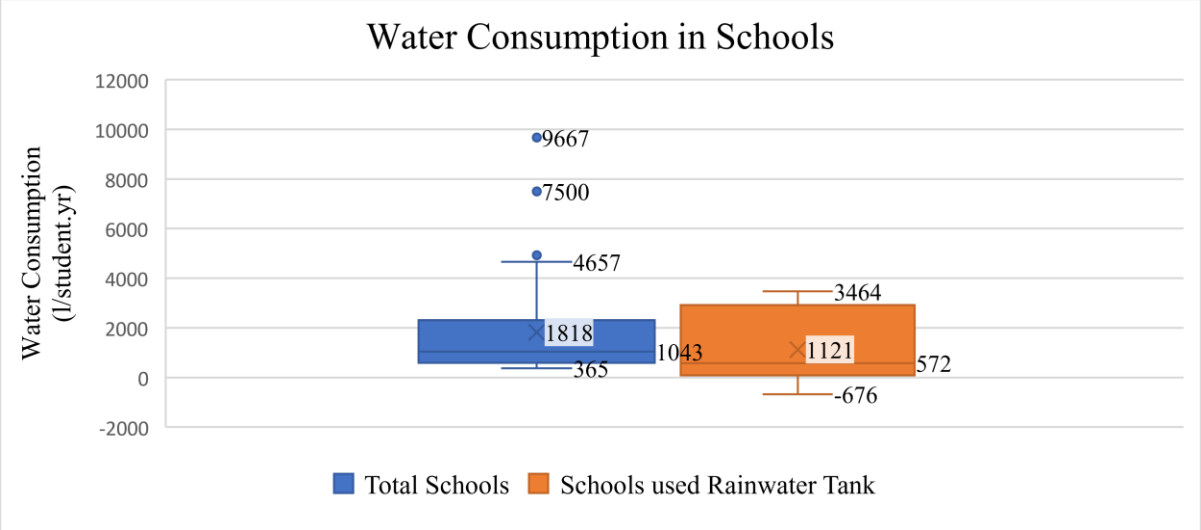

Figure 5.7. The water consumption in all schools comparing with schools used rainwater tank.

Figure 5.8 compares the water consumption of primary and secondary schools to the total water consumption of all schools. Secondary schools have a lower consumption rate of (1362 l/student.yr) than the water consumption rate in primary schools (2027 l/student.yr) with percentage 49%. This difference is expected because high school students have a higher level of awareness regarding the importance of water conservation and the need for responsible use. The water consumption in boys' schools (1516 l/student.yr) is very closed to the consumption in girls' schools (1534 l/student.yr), as shown in Figure 5.9. Figure 5.10 shows the regional impact on water consumption. It shows that the that water consumption in Tulkarm (1842 l/student.yr) exceeds that of Nablus (1748 l/student.yr). One possible explanation for this disparity is the water scarcity issue in Nablus. The city of Nablus faces more severe water shortages compared to the Tulkarm governorate. As a result, water distribution to schools and other facilities in Nablus occurs every week rather than a daily basis. This limited frequency of water supply leads to a decrease in the per capita water allocation for schools in Nablus.

Regarding the sanitation system in schools, most schools (75%) are connected to public sewers, which indicates a good sustainable point. 14 schools use septic tanks within the sewage system, which are mostly located in villages. This observation is consistent with the fact that some villages still face challenges accessing the public sanitation. However, it is reassuring to note that all sanitation systems in these schools, regardless of type, are in good condition. No problems or instances of poor sanitation systems were reported in any of the schools.

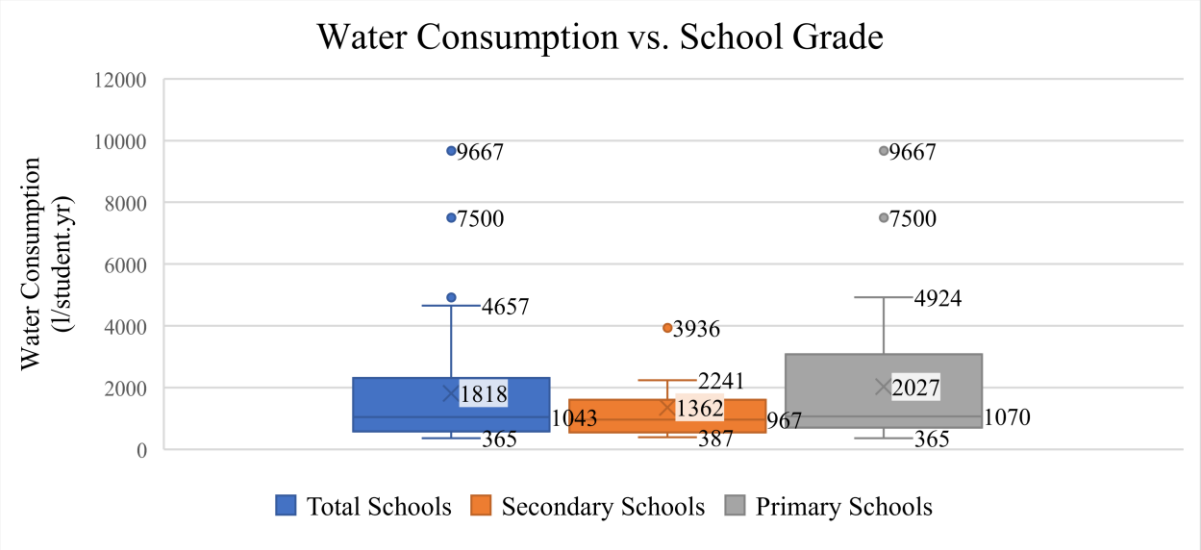

Figure 5.8. The water consumption in all schools comparing with secondary and primary schools.

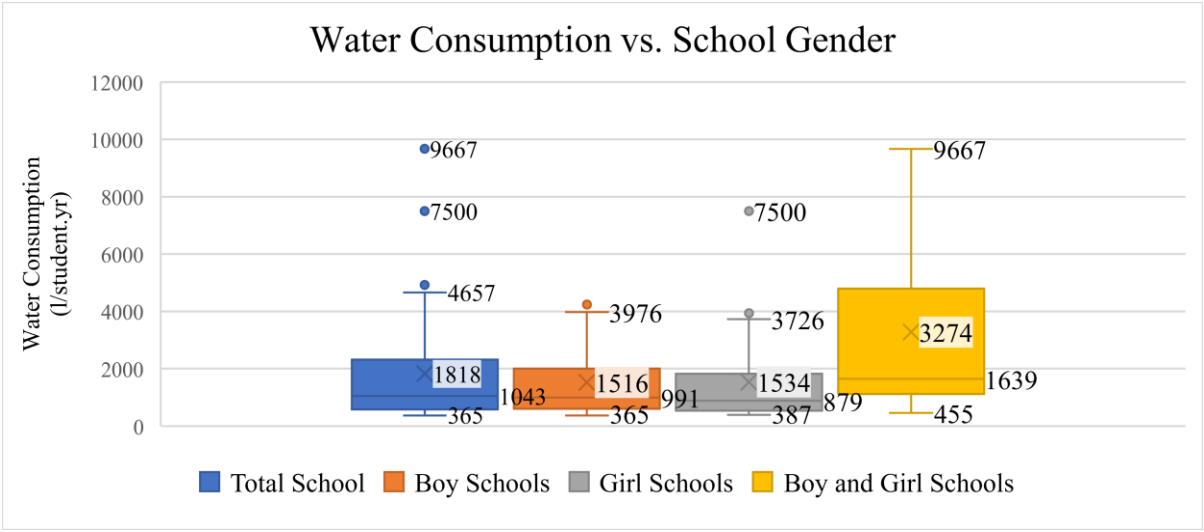

Figure 5.9. The water consumption in all schools comparing with boy and girl schools.

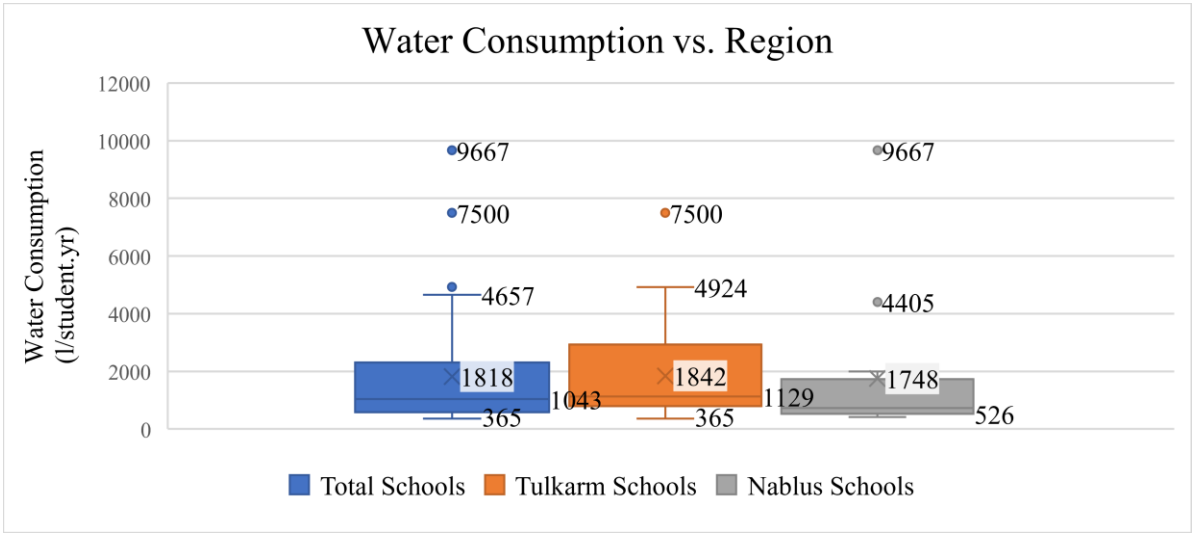

Figure 5.10. The water consumption in all schools comparing with Tulkarm and Nablus schools.

Site Development

Table 5.4 in Appendix 5 shows the indicators of site development. For several years, the school consisted of asphalt playgrounds. However, there has been a gradual shift towards improving the school environment, with an increased focus on creating green spaces, illustrated in Figure 5.11. Fruit trees and evergreens are planted, and there is a deliberate initiative to replant any trees that were on the site before excavation or construction. This demonstrates a growing commitment to creating a more environmentally friendly and aesthetically pleasing environment for schools. Figure 5.12 shows that the mean green area is approximately 8.81%. The minimum value is 0%, indicating that some schools have no green areas, while the maximum is 39%. Only two schools comply with the requirements of the Ministry of Education to allocate 30% of the land area as green spaces. The reason is the limited spaces within cities and villages, which are likely to be affected by external factors such as occupation.

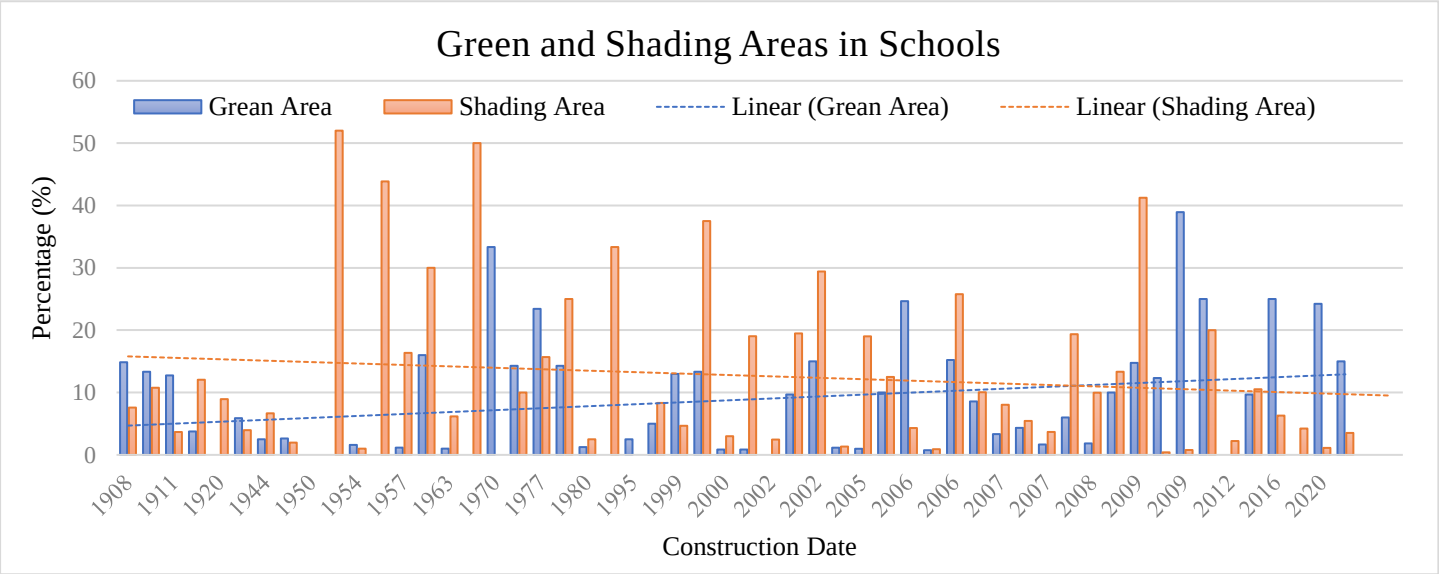

Figure 5.11. The percentage of green and shading areas in schools with the construction date.

The shading areas decrease with the year of construction as shown in Figure 5.11. Efforts were conducted to increase shading areas and reduce the use of asphalt to mitigate the heat island effect and promote environmental sustainability. The reason is that the new schools create inner courtyards in the schools, which reduces the need for shading large outdoor spaces. According to the responded schools, the mean percentage of shading areas is 13%, ranging from 0% to 52%. Various materials such as sheet metal, zinc, and polycarbonate sheets have been used for shading structures, although as of 2013, only brick awnings have been approved.

Shading of outdoor spaces in schools helps reduce the heat island effect. For further combat the heat island effect, low solar reflectance index (SRI) surfaces and tinted materials should be used in paving the play areas and outdoor spaces. However, only 11 schools (20%) have adopted this low SRI material instead of the traditional asphalt in their playgrounds. Regarding solid waste sorting in schools, it was noted that only two schools apply this practice. The reason is the absence of waste sorting systems in Tulkarm and Nablus

governorates. Thus, school waste segregation becomes ineffective due to the lack of segregation in the general waste management system. However, these two schools have taken the initiative to educate the new generation about waste sorting by implementing this practice within their schools.

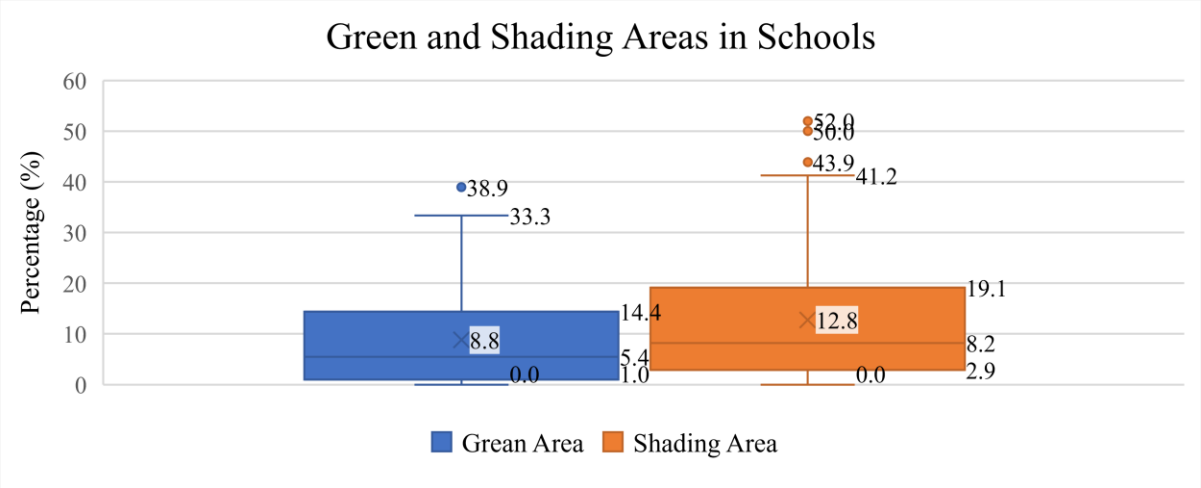

Figure 5.12. The percentage of green and shading areas in selected schools.

1. Economic Indicators

Economic indicators include maintenance cost, new employees, and financial returns from social activities. The school results of the respondents for these subjects are detailed in Table 5.5 in Appendix 5, providing a comprehensive overview. Figure 5.13 illustrates the relationship between maintenance costs and school building area. As the area of the building increases, the cost of maintenance also increases. This is to be expected, as the larger spaces require more features that require constant maintenance. The average annual maintenance cost for the surveyed schools is about $920, with the most common value in the dataset being $1,390. Maintenance costs range from a minimum of $280 to a maximum of $2,220. These expenses cover various operational aspects of the schools, such as stationery, annual maintenance tasks, and some curricular and extracurricular activities. It is important to note that these costs do not include expenditures related to energy and water use, as these expenditures are usually covered by the government through municipalities. The focus of maintenance costs revolves around the day-to-day operation and maintenance of the school facilities.

Figure 5.14 shows that boys' schools have a mean expenditure of $945 per year, while girls' schools show an average cost of $919 per year. Figure 5.15 shows that secondary schools have the lowest maintenance rate of $890 per year, while primary schools exceed the average cost for all schools of $939. Because secondary school students are usually more aware and responsible towards school facilities and the importance of preserving them. About the differences between regions as shown in Figure 5.16, the average maintenance cost of Tulkarm schools is $934, while the average for Nablus schools is $891 annually. However, the effect of gender, age, and region on maintenance costs appears to be very small compared to other factors such as building area.

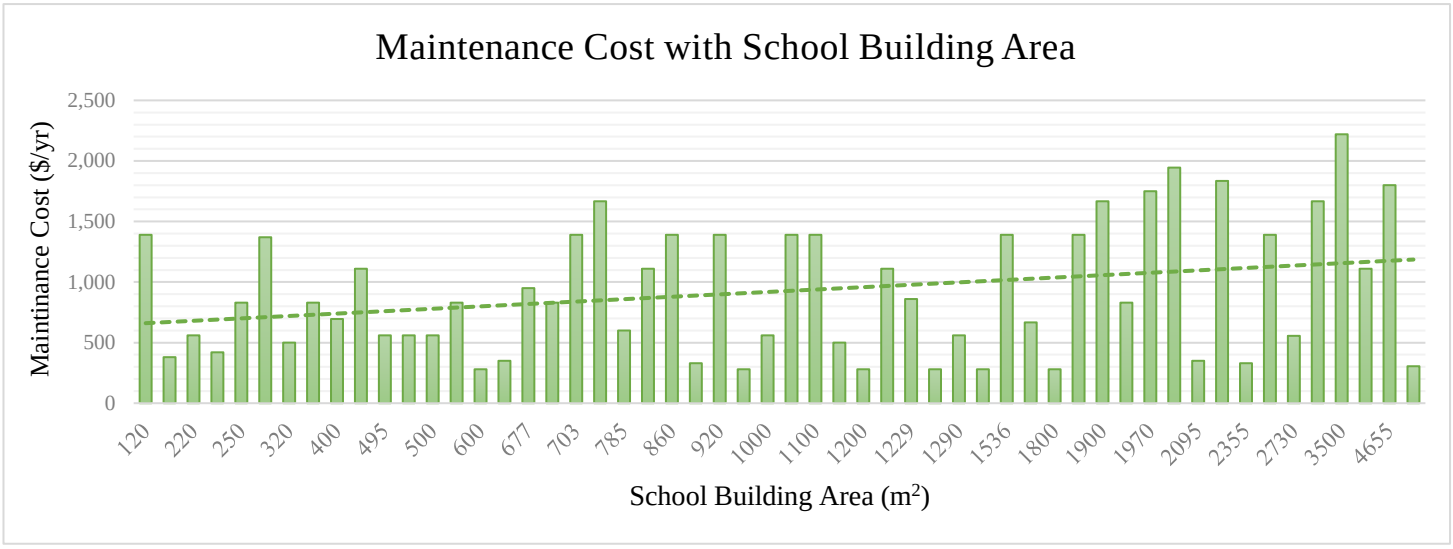

Figure 5.13. The maintenance cost of selected schools with the school building area.

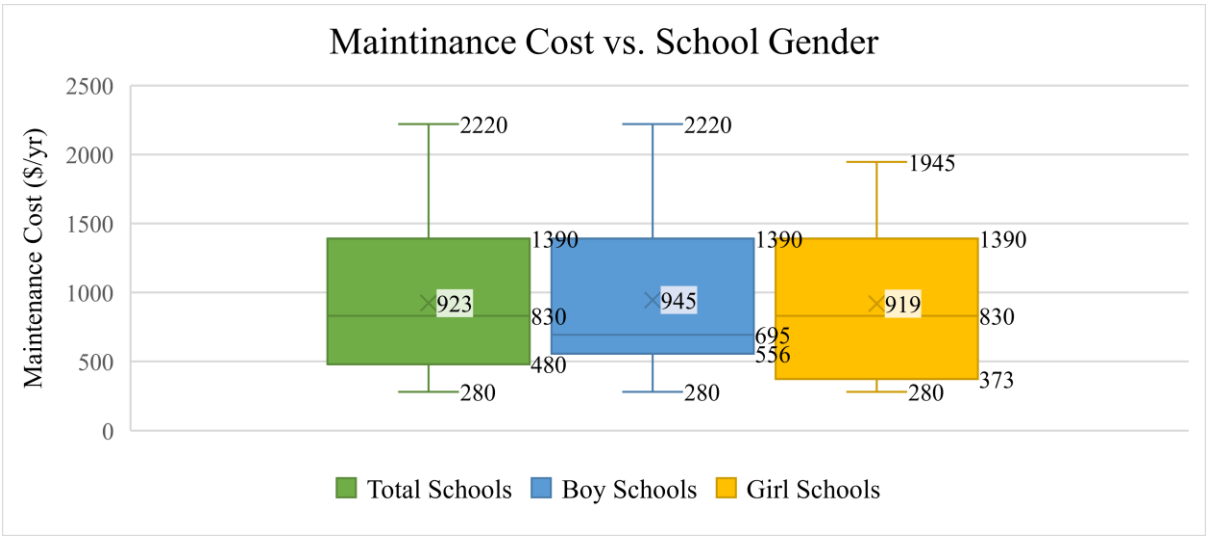

Figure 5.14. The maintenance cost in all schools comparing with boy and girl schools.

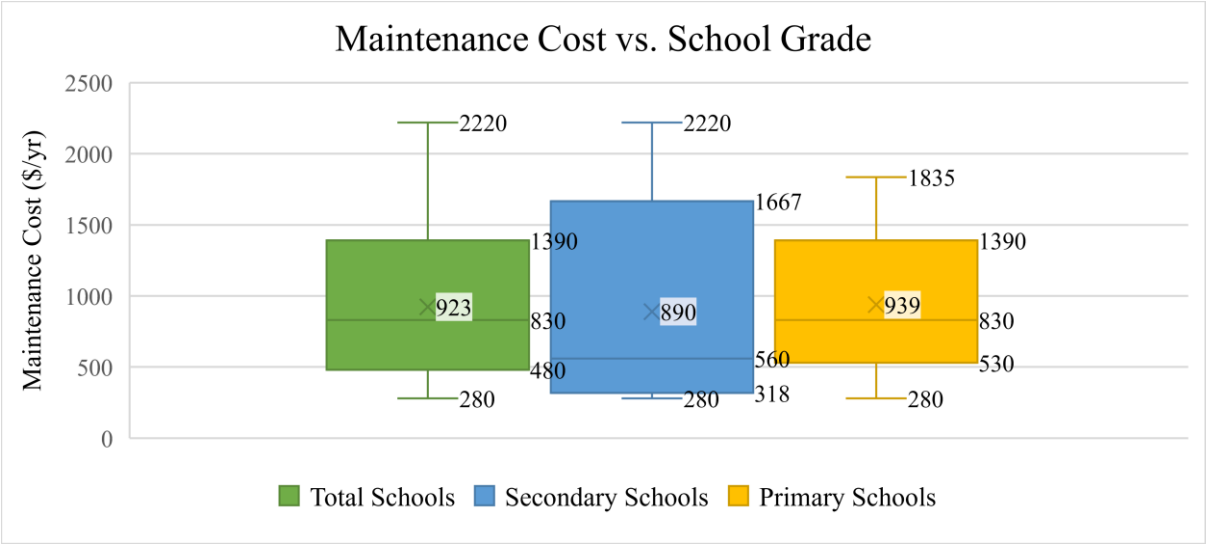

Figure 5.15. The maintenance cost in all schools comparing with secondary and primary schools.

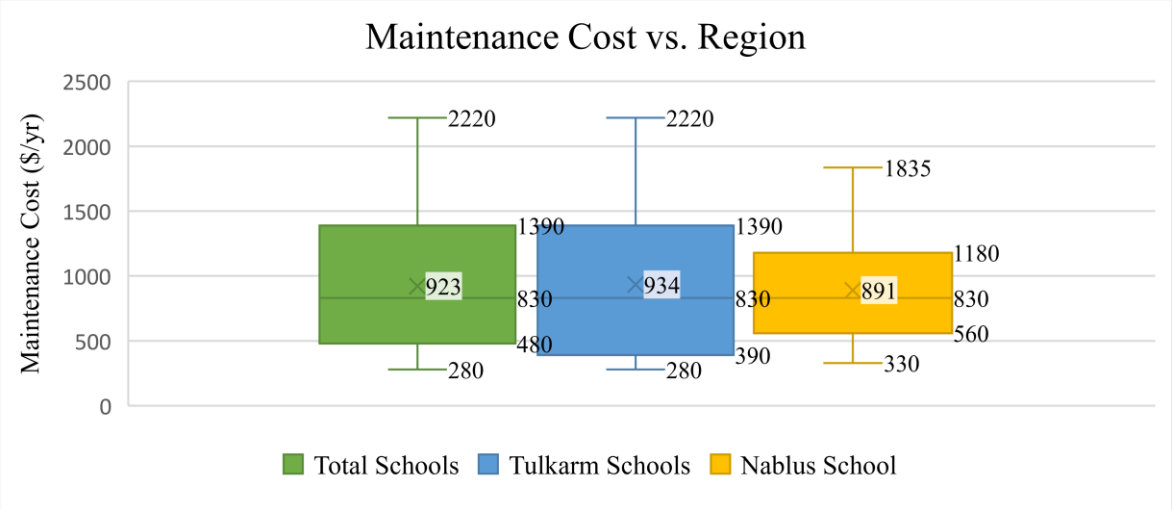

Figure 5.16. The maintenance cost in all schools compared with Tulkarm and Nablus schools.

One of the objectives of this framework is to assess the impact of schools on the local economy by examining the number of new staff members each year. It is mentioned that 32 schools, representing 59% of the sample, appointed at least one new teacher during the academic year 2021-2022. In addition, 16 schools hired new staff in their administrative departments during the same year, see Figure 5.17. These job opportunities have a significant impact on the city's local economy, contributing to job creation and economic growth. In addition, having new staff and teachers in schools brings new perspectives, ideas, and experiences. This can lead to improved teaching methods, curriculum development, and overall educational quality.

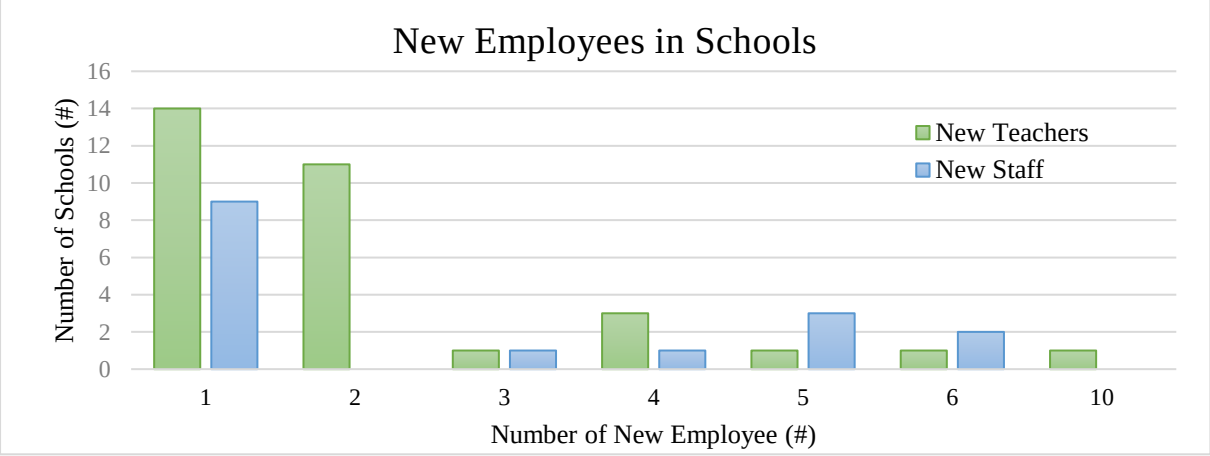

Figure 5.17. The number of new teachers and staff in schools.

Public schools, although not profit-driven, have the potential to generate financial returns through social projects conducted outside of normal school hours. Investing in school grounds and halls becomes critical to generate financial returns for the school or government. This approach not only promotes a sense of belonging but also integrates the school into the surrounding community. However, only 13 schools participated in such activities. Moreover, not all these activities generate financial returns, as the maximum declared return is $140 annually. This indicates the need for further exploration and strategic planning to effectively

utilize the financial opportunities offered by these social projects in schools.

2. Social Indicators

Public schools are designed to be affordable and attract students with limited financial resources. The data shows that all the schools surveyed have students from low-income families, albeit in varying proportions. Limited-income families are families whose monthly income is less than $520, consisting of five individuals, according to the Palestinian Central Bureau of Statistics. On average, see Figure 5.18, the proportion of low-income students in schools is about 8% with a minimum of 1% and a maximum of 32%. There is a marked disparity in the percentage of low-income students between primary and secondary schools. The proportion of low-income students in primary schools (8.20%) is higher compared to secondary schools (6.40%) by 28%. This discrepancy can be attributed to the fact that high school students often prioritize improving their financial situation by looking for jobs and, as a result, may discontinue their education. Moreover, when considering gender, the percentage of male students (5.50%) with limited income is much lower than the percentage of female students (9.80%) by 78%. This trend can be attributed to females seeking to improve their lives through education, while males tend to seek improvement through looking for job opportunities. In addition, 31 schools in the sample included students with special needs, with an average score of 1.60% and a maximum score of 9%. Based on the data presented in Figure 5.19, the percentage of students with special needs is higher in primary schools (1.80%) than in secondary schools (1.10%) by 64%. Similarly, the percentage of students with special needs in female schools (1.60%) exceeds than that of males (1.00%) by 60%. Table 5.6 in Appendix 5 provides all these data.

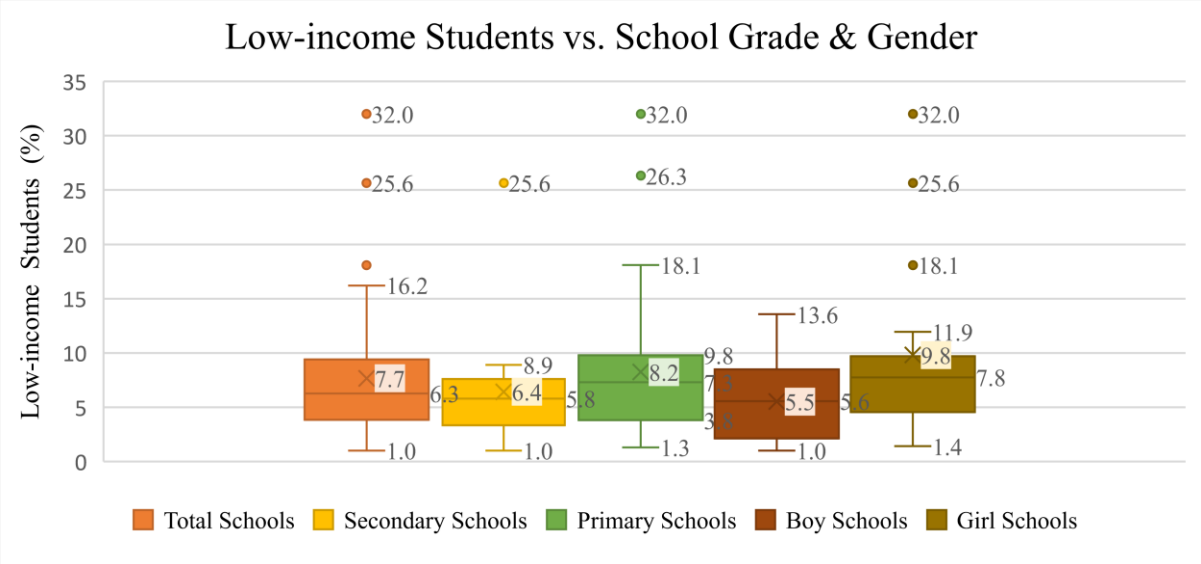

Figure 5.18. The low-income students' proportions with school grade and gender.

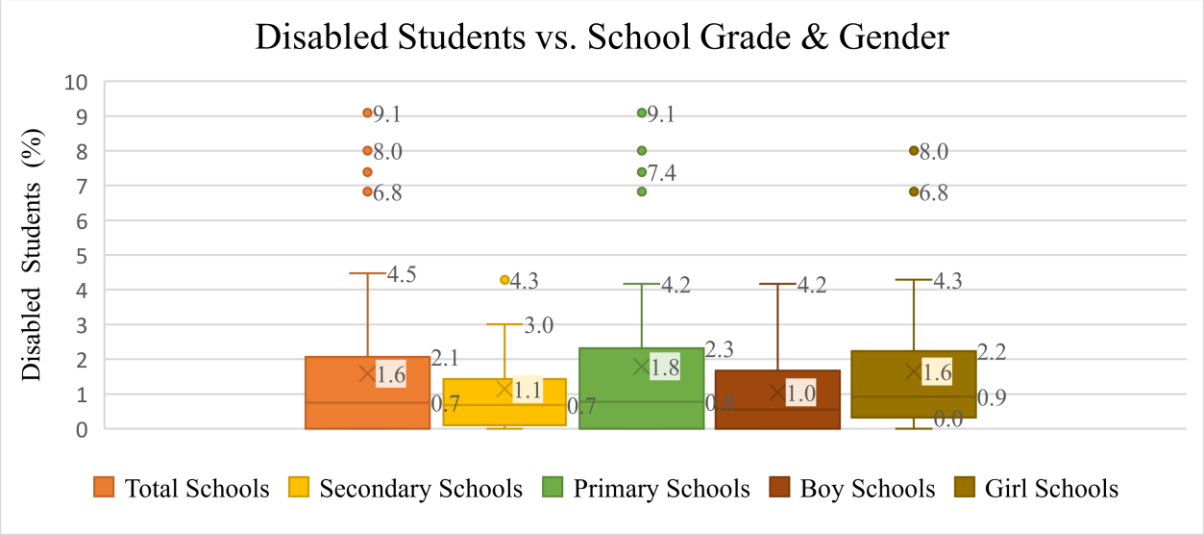

Figure 5.19. The disabled students' proportions with school grade and gender.

One of the main factors contributing to school sustainability is the concept of human-centred design. This emphasizes the participation of various stakeholders, such as teachers, students, and parents, in the decision-making process. However, in public schools, decision-making is often centralized within the Department of Education, resulting in relatively low levels of stakeholder integration. Figure 5.20 shows that the participation of teachers in decision-making is about 21.5%, with a maximum of 35%. The parental integration rate is 8.25%, and the highest is 12%. Their involvement mainly focuses on extracurricular matters, such as organizing activities for students. It should be noted that the lowest participation rate among students is, on average 3.3% and does not exceed 9%. This lack of student participation contradicts the principle of a sustainable educational system that aims to empower students with decision-making skills and responsibilities. Table 5.6 in Appendix 5 provides data all these data.

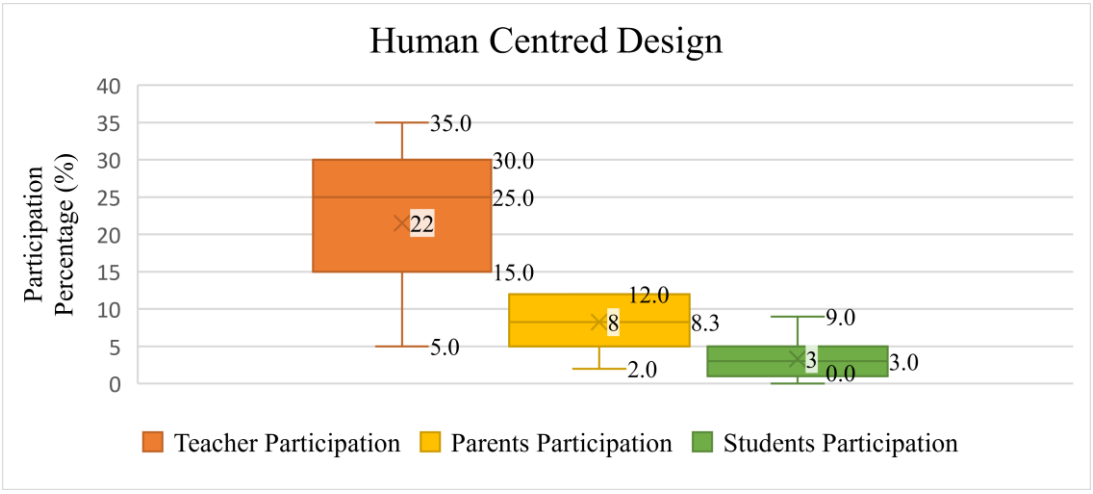

Figure 5.20. The Human Centred Design proportions in the selected schools.

Teaching quality can be assessed by various indicators, including success rate, attendance rate, school dropout rate, and sick absence rate, see Table 5.7 in Appendix 5. Figure 5.21 shows that the school attendance range ranges from 75% to 100%, averaging 92.60%. This difference can be attributed to factors associated with the accessibility of schools, particularly

on days with unfavourable weather conditions. In addition, this figure highlights that schools classified as accessible have an attendance rate of 92.8%, while schools classified as inaccessible show a slightly lower attendance rate of 91.20%. The accessibility of the school is determined by factors such as proximity to public transport, the presence of well-paved roads leading to the school, and clear entry gates. Thus, it is worth noting that the attendance rates in village schools (94.70 %) are higher than those in urban areas (91.40 %). It is clear from the results that the sick absence rate from school reached 2.94%, with a maximum of 9%. The sick absence rate is mainly related to the indoor quality of the schools and the density of students. Figure 5.22 shows that as the number of students increases, sick absence also rises, mainly because the ease of disease transmission increases.

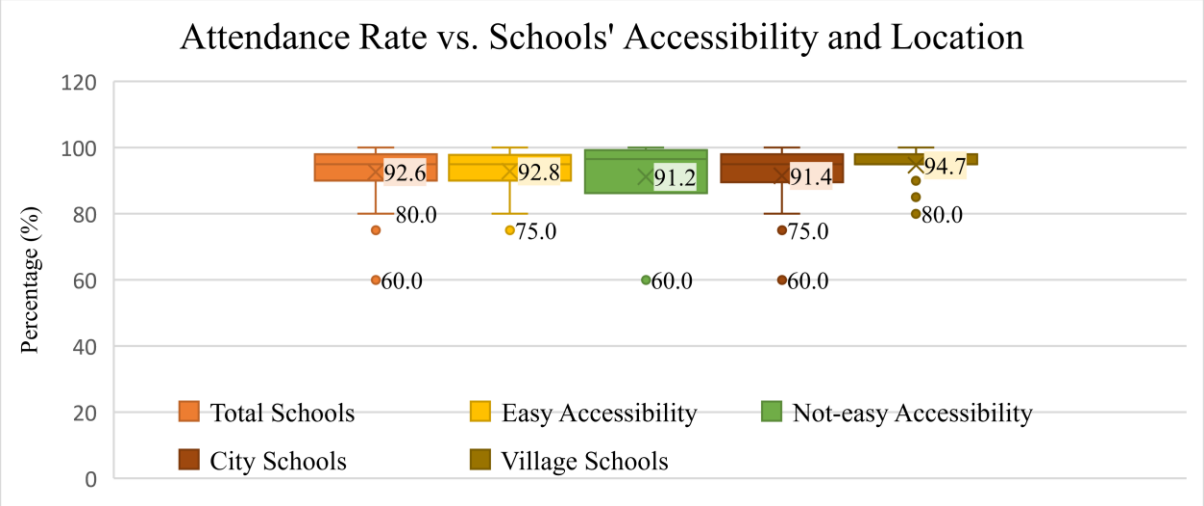

Figure 5.21. The attendance rate in schools with the schools' accessibility and location.

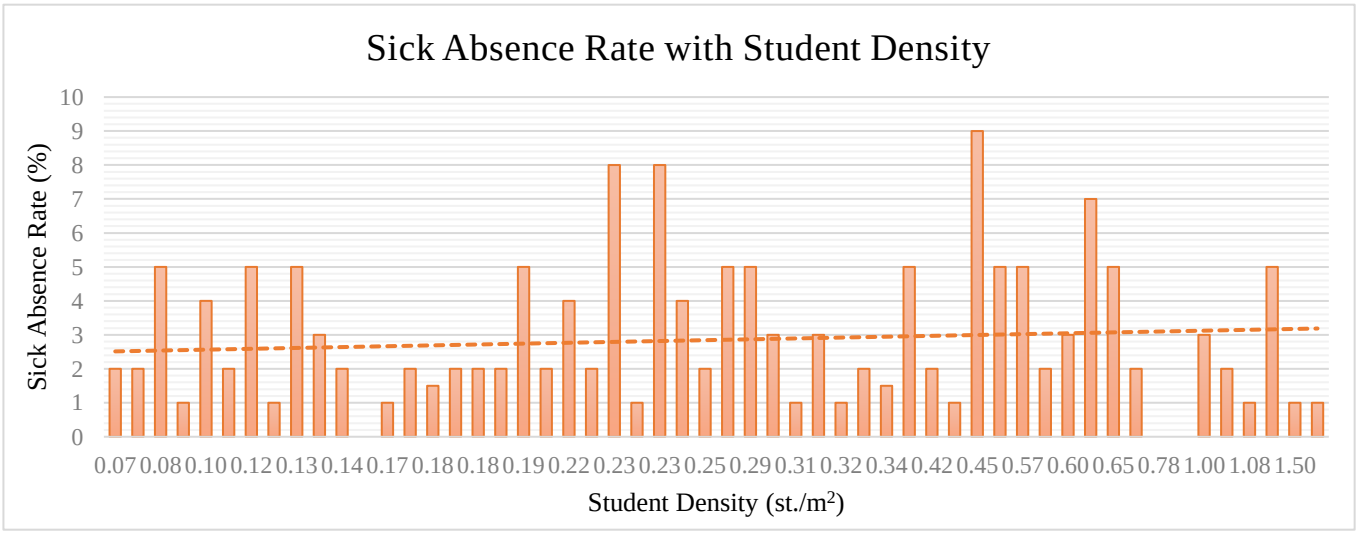

Figure 5.22. The sick absence rate in schools with student density.

The success rate is 94%, with a minimum of 75% and a maximum of 100%. This difference can be attributed to differences among students in terms of their interests and educational levels. Nevertheless, Figure 5.23 shows that the success rate in secondary schools is comparatively lower than that of primary schools. This discrepancy can be due to the nature of the curricula and their development according to educational progression. On the other

hand, there is a group of students who are forced to drop out of school due to various factors, the most important of which is the difficult economic conditions. The drop-out rate in schools is 1.25%, with a peak rate of 8%. Figure 5.24 highlights that most of these dropouts occur in secondary schools (2.60%), with a rate four times higher than that observed in primary schools. Notably, the withdrawal rate among male students (1.40%) surpasses that of females by 40%. Male students often leave school to pursue work opportunities, whereas some females discontinue their education due to marriage-related reasons.

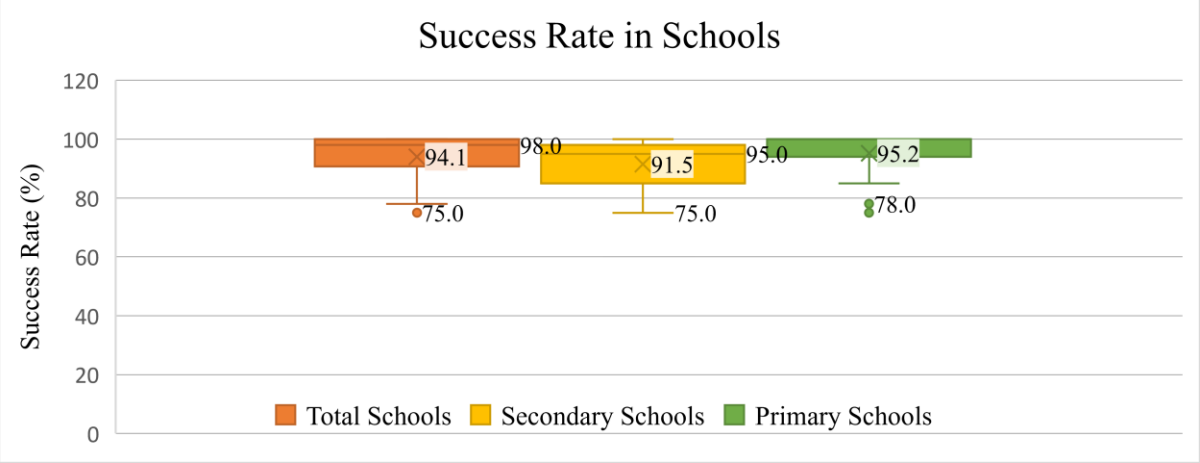

Figure 5.23. The success rate in selected schools.

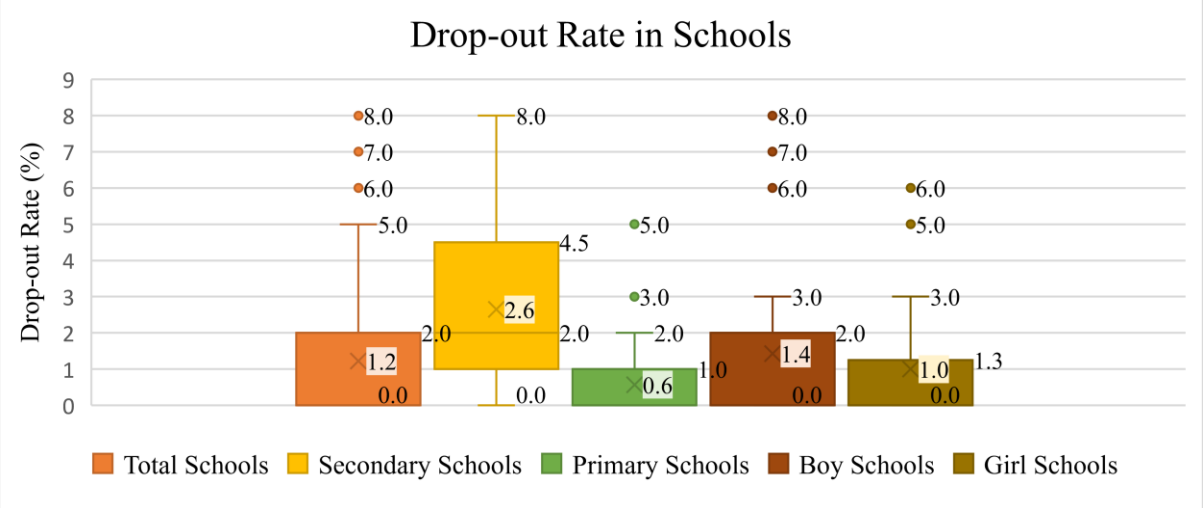

Figure 5.24. The drop-out rate in schools with the schools' grade and gender.

Data reveals that only 10 schools (19%) have car parks for school staff. The average parking percentage is relatively low, at 5.7%, with some cases reaching a maximum of 58%. Figure 5.25 indicates that parking availability is affected by two factors: the size of the school and the construction date. Schools with larger spaces can accommodate more parking spaces for teachers. Likewise, new school buildings tend to contain more parking spaces than older buildings. This is in line with the recent regulations by the Ministry of Education, which emphasizes the requirements for designated parking spaces in schools.

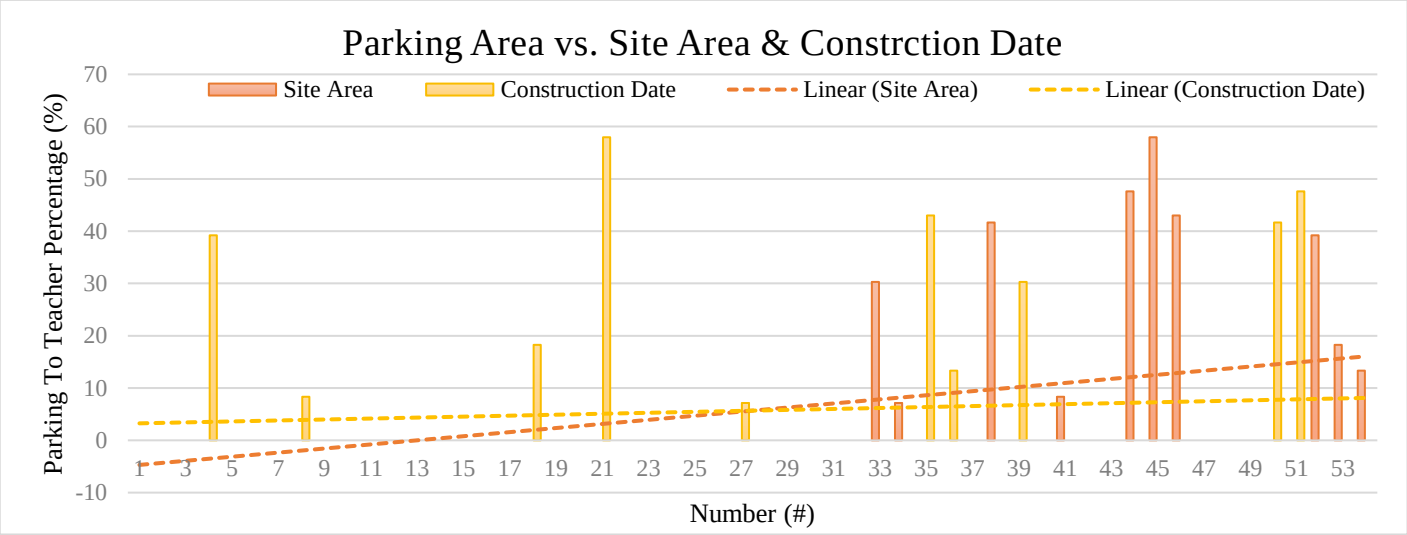

Figure 5.25. The parking area in schools with school site area and construction date.

5.3 Sustainability Index

The aim of this section is to evaluate the sustainability of schools in Palestine using the sustainability index. The study examines a number of values of the sustainability index, descriptive statistics, as well as ideal and worst-case scenarios and the special case. The results contribute to the understanding of the current state of sustainability practices in Palestinian schools and provide a basis for future improvement. The sustainability index was calculated based on the data collected from the schools selected for the environmental, economic, and social indicators. In addition to the weightings of these criteria and indicators determined by the opinions of experts.

5.3.1 Sustainability Index Analysis

The sustainability index values obtained from the sample of Palestinian schools are presented in Table 5.1. These values range from a minimum of 0.229 to a maximum of 0.479. These values indicate the extent to which schools in Palestine are adopting sustainable practices, with higher index values indicating higher levels of sustainability. This range shows how close the schools are in terms of sustainability, indicating that the schools are designed to the same standards and use the same practices.

The mean of the sustainability index is 0.343, and the median of the sustainability index distribution is 0.338, which means it is close to the mean. In addition, the standard deviation is 0.059, which means that the values of sustainability index vary greatly in the studied schools. The standard error is 0.01, indicating that the mean of the sustainability index is probably a reliable estimate of the population mean. The closeness of the mean and median, as well as the small standard deviation and standard error, suggest a relatively uniform level of sustainability practices across schools. This similarity suggests that schools adhere to common standards and use comparable practices when implementing sustainable initiatives.

In addition, the skewness value of 0.42 indicates a slightly positively skewed distribution. This means that the distribution of sustainability index scores is slightly skewed toward higher scores, indicating that some schools have higher sustainability practices. The kurtosis

value of -0.52 indicates a slightly platykurtic distribution. This means that the sustainability index values have a lighter tail and are less peaked compared to a normal distribution. It suggests that the distribution is somewhat flatter, with a smaller proportion of extreme values.

Table 5.1. The sustainability index for selected schools and its rank.

Sustainability School Index					
School No.	**Rank**	**Sus. Index**	**School No.**	**Rank**	**Sus. Index**
Worst Case	Min. value	0.082	**28**	21	0.340
1	36	0.229	**29**	17	0.340
2	54	0.247	**30**	30	0.344
3	5	0.250	**31**	4	0.349
4	9	0.270	**32**	25	0.349
5	47	0.274	**33**	22	0.350
6	39	0.276	**34**	3	0.352
7	52	0.286	**35**	32	0.361
8	18	0.287	**36**	40	0.362
9	37	0.289	**37**	48	0.363
10	38	0.292	**38**	20	0.366
11	7	0.293	**39**	45	0.377
12	19	0.295	**40**	14	0.377
13	26	0.297	**41**	34	0.379
14	53	0.297	**42**	27	0.389
15	11	0.299	**43**	28	0.393
16	1	0.300	**44**	13	0.400
17	50	0.302	**45**	24	0.402
18	31	0.304	**46**	33	0.411
19	10	0.307	**47**	12	0.419
20	51	0.311	**48**	42	0.423
21	41	0.312	**49**	44	0.439
22	43	0.314	**50**	15	0.440
23	46	0.314	**51**	23	0.440
24	29	0.317	**52**	16	0.450
25	2	0.331	**53**	35	0.456
26	49	0.332	**54**	8	0.479
27	6	0.336	**Ideal Case**	Max. value	0.855

These findings may suggest that the policies or measures implemented by the education system in Palestine support sustainability to some extent and that there is some level of commitment by schools to adhere to these policies. However, more effort and further commitment is needed to increase the overall level of sustainability in Palestinian schools. This indicates that further improvements and initiatives are needed to strengthen sustainability practices and ensure more consistent and comprehensive implementation throughout the education system.

Figure 5.26 provides a comprehensive overview of the results discussed earlier and shows the distribution of the sustainability index scores across the schools in the sample. The figure provides a visual representation of how close these scores are to each other, allowing for a clear understanding of the similarities or differences in their sustainability practices. It also includes information about the ideal sustainable school and the worst-case scenario, which shows the range of sustainability practices in the schools. This serves as a benchmark and provides information on how well the schools studied match the ideal scenario or tend toward the worst case. Furthermore, the figure highlights a remarkable case, specifically a Palestinian public school that has a gold classification according to the Palestinian Green Building Guide. This case serves as a reference point, presenting the sustainability achievements of this school in the context of the broader distribution of indicator values. All these critical aspects, including the min. and max. values of sustainability index, ideal and worst-case scenarios, and the unique case of the gold-rated Palestinian public school, will be explored in detail in the following subsections. Figure 5.26 serves as a visual aid to facilitate a comprehensive understanding of these key elements and their interrelationships.

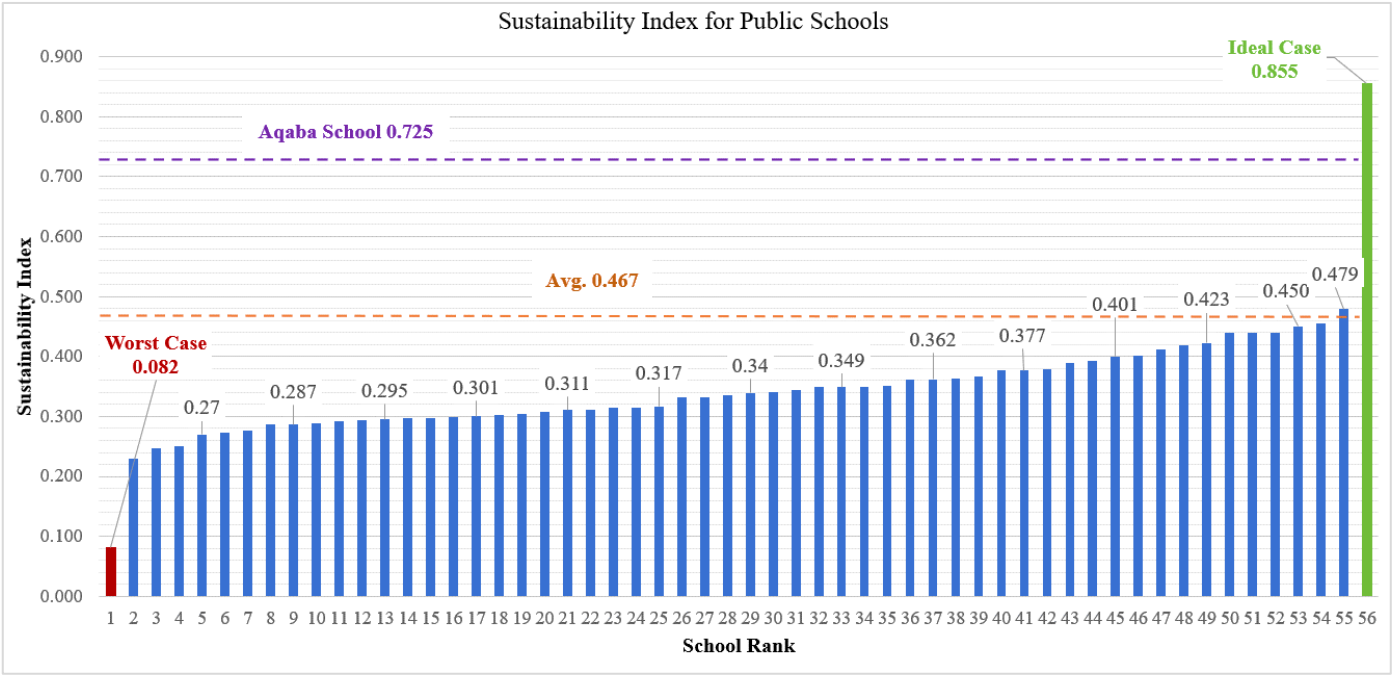

Figure 5.26. The sustainability index for Palestinian public school.

According to the results presented in Figure 5.27, the sustainability index for secondary schools is very close to that of primary schools (6% lower). This contradicts the concept that secondary schools, being more aware and responsible, will exhibit higher levels of sustainability. However, the reason behind this discrepancy lies in the fact that the sustainability of primary schools is primarily influenced by social rather than environmental indicators. While secondary schools show significantly lower energy and water consumption, primary schools excel in social inclusion, which is very important according to expert opinions presented in Chapter 4. Regarding to schools' gender, there is no noticeable difference between female and male schools in terms of sustainability. This is because there is

a clear convergence between these schools in terms of all aspects of environmental, economic, and social sustainability.

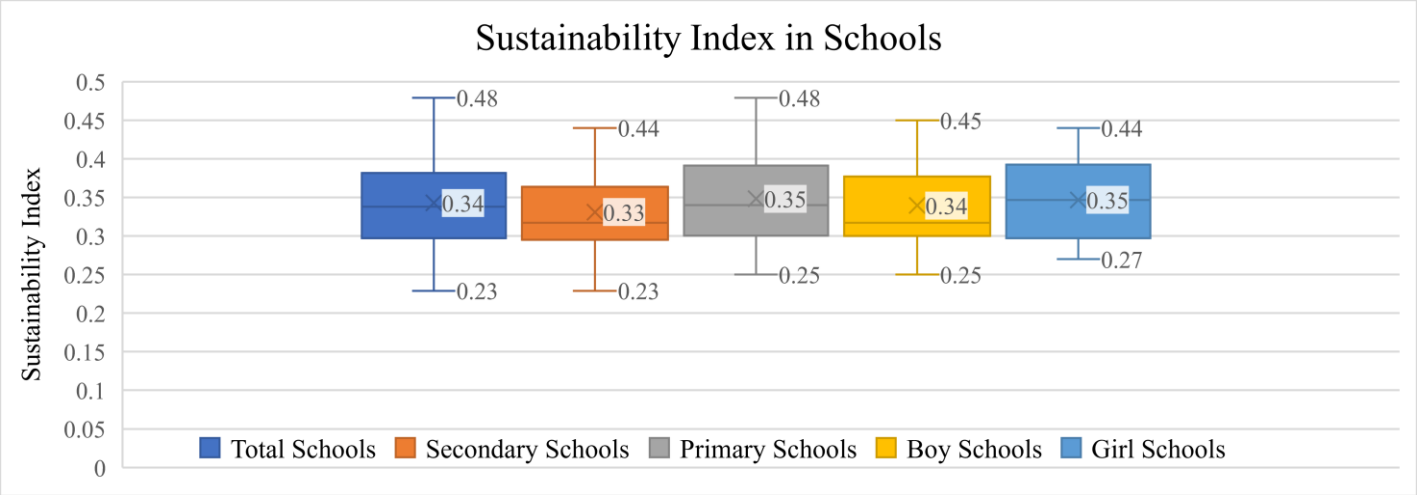

Figure 5.27. The sustainability index with the schools' grade and gender.

5.3.2 The Schools with Max., Avg., and Min. Sustainability Index

This subsection focuses on examining the characteristics of the schools that achieved the highest, average, and lowest sustainability index scores among the schools in the sample. The main objective is to understand the particular characteristics and indicators that contributed to the ranking of each school. Details on these characteristics can be found in Table 5.2, which provides a comprehensive overview of the scores associated with each category.

School I (maximum index) places a stronger focus on environmental aspects than school III (minimum index). For example, energy consumption is low (4.3 kWh/m^2), almost half that of school III (11 kWh/m^2). This is achieved by using solar panels to generate energy. School I also has insulation on the building envelope and shading on the south and east facades, while school III does not. In terms of water consumption, the first school uses 1,385 liters per person, almost a third of the consumption in the school III (4,234 liters). In addition, the first school has a rainwater collection tank with a capacity of 24 cups.

Regarding the development of the site, the first school has a green area of 1,000 square meters, which represents 25% of the total area. In contrast, the second III has only 30 square meters of green area, which is only 2% of the total area. In addition, School I uses low solar reflectance index materials in play areas and courtyards to reduce the heat island effect. The second school, on the other hand, uses asphalt surfaces that increase the heat island effect.

From a social perspective, there are notable differences between the two schools. The first school has an easily accessible 150 m^2 parking lot, which the second school does not have. In addition, the first school has proven successful in attracting low-income students, with 7% of its students falling into this category. In addition, the III school has a higher success rate of 100% compared to the 98% of the III school. However, in terms of human-centered design, the III school is about the same as the former. Parent participation in decision making is 12% in both schools. Teacher participation is 30% in the first school and 20% in the third school.

In terms of health and well-being, School I provides a healthy environment. The sickness absence rate there does not exceed 2%, while in the school III it reaches 5%.

As for the economic aspect, School I generates additional income through social activities outside normal working hours, resulting in an annual financial return of $150. In addition, School I had a positive impact on the local economy by hiring five new teachers during the 21-22 school year. In contrast, the III school hired only one new teacher during the same time period. Both schools share the same annual maintenance costs, which are approximately $560.

When examining the school II, which represents the school with a medium sustainability index, remarkable observations can be made. For some indicators, the school II is similar to the school III (minimum score), while for other indicators it even surpasses the first school (maximum score). The school performed exceptionally well, especially in the very important indicators such as social inclusion, energy consumption and water consumption. This performance is the reason for its score.

As for energy consumption, the school II consumes only 1.99 kWh/m^2 annually. However, this school lacks some energy saving features such as thermal insulation, solar panels and shading on the facade. As for water consumption, the school II consumes only 589 liters/person per year, which is almost half of the consumption of the first school. This indicates a conscious effort to use water resources efficiently. As for other environmental indicators, the green area of the school II is only 40 m^2, which is only 1% of the total area. In addition, the school has only two parking lots and uses asphalt as a raw material for paving the areas.

Regarding the social indicators of the school II, the school has achieved an impressive level of inclusion of low-income students. The percentage of these students is 26% out of a total of 100 students in the school. Since social inclusion is of great importance in the sustainability index, this high percentage contributed significantly to the school's overall score. In addition, the rate of student, teacher, and parent participation in decision-making is between that of School I and School III. This indicates that the school II has moderate levels of engagement and collaboration among its key stakeholders.

Economically, it has relatively high maintenance costs of $1,667. In addition, the school provides social activities outside of working hours. While these activities contribute to social well-being and student and community involvement, they do not generate financial gain. These characteristics indicate the areas in which the school II is excelling and the areas in which further attention and improvement may be needed.

This is an important finding that underscores the importance of taking a balanced approach when striving for a sustainable school. It is suggested that rather than focusing only on excellence in specific categories, all indicators should be considered at a satisfactory level. With a holistic approach, schools can achieve a comprehensive and well-managed state of sustainability, creating a conducive learning environment that benefits students, staff, and the surrounding community.

Table 5.2. The comparison among schools with max., avg., and min. sustainability index.

Comparison between the Max., Avg., and Min. Sustainability Index			
	School with Max. Sus. Index	**School with Avg. Sus. Index**	**School with Min. Sus. Index**
Sustainability Index	**0.479**	**0.344**	**0.229**
School Number	**8**	**30**	**36**
School Name	**School I**	**School II**	**School III**
Indicator	**Value**		
Energy consumption	4.30 KWh/m^2. yr	1.99 KWh/m^2. yr	11.00 KWh/m^2. yr
Use of solar panel	Yes (20 KWh)	No (0)	No (0)
Building envelope insulation	Yes (1)	No (0)	No (0)
Shading on elevations	Yes (1)	No (0)	No (0)
Water consumption	1,385 L/person. yr	589 L/person. yr	4,234 L/person. yr
Use of Rainwater tank	Yes (24 m^3)	No	No
Green area	1,000 m^2 (24%)	40 m^2 (1%)	30 m^2 (2%)
Heat island effect	Low SRI surface	Asphalt	Asphalt
Parking area	150 m^2 (10 parking spaces)	30 m^2 (2 parking spaces)	0 m^2
Accessibility	1 (easy)	1 (easy)	0 (not easy)
Low-income students	13 student (7%)	100 student (26%)	6 student (3%)
Teacher participation	30 %	25 %	20 %
Student participation	5 %	2 %	0 %
Parents participation	12 %	10 %	12 %
Absence sick rates	2 %	3 %	5%
Success rate	98 %	95 %	100 %
New teacher employment	5	0	1
Social activities	Yes ($150)	Yes ($0)	No ($0)
Maintenance cost	$ 556	$1,667	$ 560

5.3.3 Ideal-Case and Worst-Case Scenarios

The ideal case scenario serves as a reference standard that indicates the desired goal of sustainability practices in Palestinian schools. It summarizes the standard to which schools should aspire in order to achieve optimal sustainability performance. In contrast, the worst case scenario represents the lowest observed level of sustainability in the schools studied. It serves as a reference point for identifying areas where significant improvement is needed and serves as a reminder of the importance of strengthening sustainability efforts. Identifying these cases helps to identify where the selected schools stand in terms of sustainability. The determination of optimal and worst scores was based on a careful review of international assessment tools, contextual factors specific to Palestine, and available data. The corresponding optimal and worst values for each indicator can be found in Table 5.3, which provides a comprehensive overview of the most desirable and least desirable results for each of the sustainability indicators. It also shows the reference of all these values.

Table 5.3. The ideal and worst values for indicators.

Comparison between the Ideal and Worst Value for Sustainable indicators						
No.	**Indicator**	**Unit**	**Ideal Value**	**Reference**	**Worst Value**	**Reference**
1.	Energy Consumption	KWh/m²	0	International code (International Energy Agency (IEA))	51	The max. value in the selected data
2.	Solar Panel	0 or 1	Used (1)	Palestinian Green Building Guideline	Not Used (0)	The worst case
3.	Insulation in Envelope	0 or 1	Used (1)		Not Used (0)	
4.	Shading in South Elevation	0 or 1	Used (1)		Not Used (0)	
5.	Shading in East Elevation	0 or 1	Used (1)		Not Used (0)	
6.	Shading in West Elevation	0 or 1	Used (1)		Not Used (0)	
7.	Water Consumption	L/person. yr	0	International code	9667	The max. vale in the selected data
8.	Rainwater Tank	0 or 1	Used (1)	Palestinian Green Building Guideline	Not Used (0)	The worst case
9.	Sanitation	0 or 1	Public Sewage (1)	The ideal case	Septic Tank (0)	The worst case
10.	Sanitation Efficiency	0 or 1	Perfect (1)	The ideal case	Good-Normal (0)	The worst case
11.	Green Area	%	30	Palestinian Green Building Guideline	0	The min. value in the selected data
12.	Shading Area	%	50	Palestinian Green Building Guideline	0	The min. value in the selected data
13.	Parking area	%	70	Palestinian Green Building Guideline	0	The min. value in the selected data
14.	Access to Public Transportation	m	400	Palestinian Green Building Guideline	3000	Palestinian Green Building Guideline
15.	Accessibility	0 or 1	Easy (1)	The ideal case	Not Easy (0)	The worst case
16.	Heat Island Effect	0 or 1	Low SRI Surface (1)	Palestinian Green Building Guideline	Asphalt (0)	The worst case
17.	Waste Separation	0 or 1	Used (1)		Not Used (0)	
18.	Maintenance Cost	$/yr	$ 270	The min. vale in the selected data	$ 2200	The max. value in the selected data

19.	New Teachers	#	10	The max. value in the selected data	0	The min. value in the selected data
20.	New Staff	#	6	The max. value in the selected data	0	The min. value in the selected data
21.	Social Activities	0 or 1	Used (1)	The ideal case	Not Used (0)	The worst case
22.	Low-income students	%	32	The max. value in the selected data	0	The min. value in the selected data
23.	Disabled students	%	9	The max. vale in the selected data	0	The min. value in the selected data
24.	Teacher Participation	%	35	Palestinian Ministry of Education Rules	0	The worst case
25.	Parents Participation	%	15		0	
26.	Students Participation	%	20		0	
27.	Attendance Rates	%	100	The max. value in the selected data	60	The min. value in the selected data
28.	Absence rates due to illness	%	0	The min. value in the selected data	9	The max. value in the selected data
29.	Success Rate	%	100	The max. value in the selected data	50	The min. value in the selected data
30.	Dropout Rate	%	0	The min. value in the selected data	8	The max. value in the selected data

The sustainability index shows that the ideal case reaches a value of 0.855, while the worst case scenario corresponds to a value of 0.082. On average, the sustainability index value for these scenarios is 0.467. The sustainability performance of most schools (96%) is below this median value, which is between the best and worst sustainability scenarios. Only two schools are slightly above the average, albeit only slightly. However, it is important to recognize that all schools perform better than the worst case scenario. This shows that progress is being made toward sustainability, although there is still room for improvement. This underscores the need to make significant environmental, social, and economic progress to improve the overall sustainability of Palestinian schools.

The progress these schools have made toward sustainability is promising but requires collaboration between internal and external stakeholders to achieve long-term sustainable practices. This collaboration among teachers, administrators, students, parents, and the broader community is critical to creating significant change and fostering a sustainable learning environment. This framework defines key indicators and desired values and provides guidance for achieving sustainability goals. It provides valuable insights to the ministry or government on the ideal framework for Palestinian schools striving for sustainability.

5.3.4 Special Case – Aqaba School

Currently, there are no schools in Palestine that are considered fully sustainable. However, there is a unique case of a school that has received the Gold classification based on the Palestinian Green Building Guide. This school is the Aqaba School. Therefore, it is

interesting and useful to study the specifications and characteristics of this school. In addition, it is necessary to evaluate the environmental, social and economic impacts that have developed in the 5 years since the construction of the school. This research will provide valuable insights into the consequences of implementing sustainable specifications, not only for the school itself, but also for the broader community, including broader impacts on environmental protection, social well-being, and economic considerations.

The Aqaba School in the West Bank village of Aqaba received a Gold rating with an overall score of 146 out of 200 (Palestine Higher Green Building Council, 2013). It is important to emphasize that the design of the school focuses mainly on the environmental aspects of the buildings, while not much attention was paid to the social and economic aspects during the design process. This is because the Palestinian green building guidelines only focus on environmental aspects and do not include the broader area of sustainability. For a comprehensive understanding of the characteristics and features of these schools, Table 5.4 provides a detailed overview.

Table 5.4. The characteristics and environmental indicator values for Aqaba School.

Aqaba School Information			
Name		**Green Aqaba School**	
Grade		Secondary School	
Gender		Girls	
Student Number		172 Students	
Teacher Number		16 Teachers	
Staff Number		5 Persons	
Site Area		2000 m^2	
Building Area		1408 m^2	
Establishment Year		2017	
Funding Body		USAID	
Indicator	**Value**	**Indicator**	**Value**
Energy Consumption	4.19 KWh/m^2. yr	**Water Consumption**	1,606 L/person. yr
Solar Panel	12,400 KWh/yr	**Rainwater Tank**	70 m^3
Insulation Building Envelope	Used (1)	**Greywater Recycling**	Used for Irrigation
Shading in South elevation	Used (1)	**Green Area**	15 %
Shading in East elevation	Used (1)	**Shading Area**	30% from outside area
Shading in West elevation	Used (1)	**Parking Area**	5 parking spaces
Heat Island Effect	Low SRI Surface	**Bicycle Parking**	10 parking spaces

Waste Separation	Used (1)	**Accessibility**	Easy (1)

The table shows that the school paid particular attention to environmental aspects during the design phase. However, not only in the environmental aspects, but also in the socio-economic dimensions, remarkable improvements were observed after the operation of the school. One of the outstanding features of the school is its high quality facilities as in private schools, while the school fees remain affordable as in public schools. As a result, the school has succeeded in attracting low-income students who might not otherwise have had access to such educational opportunities. In addition, it is a desirable institution for students with disabilities. It offers extensive facilities designed to meet their special needs. In particular, it has two main entrances specifically designed for them, one of which provides direct access to the first floor and the other easy access to the second floor. The school's exceptional interior has also made it a popular venue for social activities that take place outside of normal school hours and foster an engaging community atmosphere. In addition to the financial returns from these activities.

This high school has exceptional success rates in several academic departments. Most notably, the science department has a remarkable 100% success rate, with 61% of students achieving the highest grade of A+. The literary department also has a commendable 87% success rate, while the entrepreneurship and business department has an impressive 93% success rate. Active student participation in decision-making is another noteworthy aspect of this school. Students are involved in 25% of decisions related to student activities, giving them the opportunity to have an opinion and help shape their educational experience. Parents also play an important role, participating in 30% of decisions related to student services and activities, which strengthens the partnership between the school and families. Teachers are actively involved in 100% of academic decisions and 50% of administrative decisions, demonstrating their commitment to shaping the educational environment. This high level of student, parent, and teacher participation represents the exceptional level of engagement achieved by educational institutions.

Economically, the school has brought remarkable benefits to the local community. One important benefit is the school's ability to produce twice the amount of energy used per month. With a monthly consumption of 700 to 900 kWh, the school's solar panels generate 1,500 kWh. This excess capacity is then transferred to the community, which can sell it and make a profit on the excess capacity. This economic profit contributes to the financial well-being of the local community.

Based on our sustainability assessment framework, Aqaba School achieved a commendable score of 0.729, indicating its proximity to the ideal case. This result confirms the existence of direct and indirect correlations between the three pillars of sustainability and highlights the importance of integrating social and economic considerations in the design phase along with environmental factors. Another factor contributing to the success of the school is the subsequent continuous monitoring and supervision by the Ministry and the Municipality. This dedicated monitoring has been instrumental in maintaining the school's excellence, fostering continued progress, and achieving impressive results.

5.4 Indoor Environmental Quality Assessment

This section is about the analysis of data on the quality of indoor environment based on students' opinions. The data was collected from 331 students, 200 students from Tulkarm (60%) and 131 students from Nablus (40%). These students are from upper primary and secondary schools. In addition, approximately 51% of the respondents are female and the rest are male. As described in Chapter 3, students in this analysis commented on various aspects of indoor environmental comfort. These aspects include thermal comfort, which refers to the feeling of not being too hot or too cold. In addition, the study also examined the quality of the indoor environment, including factors such as lighting, acoustics, and air quality, all of which significantly affect student comfort and productivity. In addition, the study also considered ergonomic comfort, which is critical for optimal physical support and standing during tasks. This section presents the results of these considerations.

5.4.1 Thermal Comfort Analysis

In most public schools, the lack of dedicated heating and cooling equipment has resulted in less than ideal thermal conditions. This deficiency is most noticeable in winter, when students often resort to extra layers of clothing to compensate for inadequate heating (see Figure 5.28). Only a small percentage (about 14%) of schools have taken steps to address this problem by installing electric heaters to provide some level of heat regulation, as shown in Figure 5.28. However, this low level of adoption highlights the greater difficulty in maintaining an adequate temperature throughout the school year.

With summer approaching, a large portion (around 75%) of students feel uncomfortable due too hot or too hot inside their classrooms. The lack of effective cooling mechanisms becomes acutely evident, affecting the learning environment and well-being of the students. By contrast, during the winter season, approximately 69% of students expressed dissatisfaction with the temperature of classrooms, considering it to be either cold or too cold, see Figure 5.29.

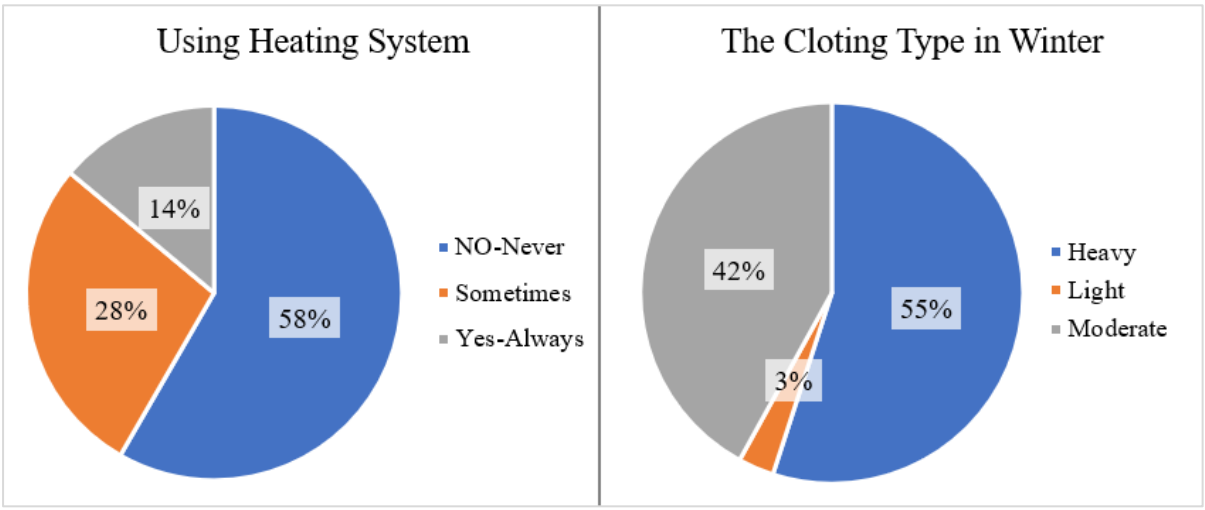

Figure 5.28. The proportion of using heating system and the clothing type used in winter based on students' opinions.

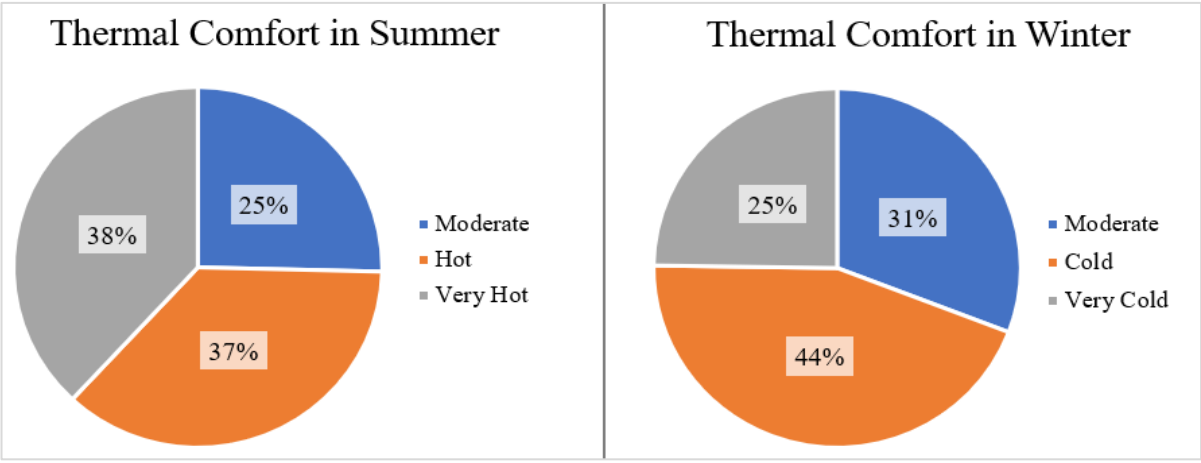

Figure 5.29. The thermal comfort in summer and winter within the classrooms based on students' opinions.

One of the main reasons contributing to the observed results is financial constraints. The enormous initial cost of HVAC systems and the ongoing operational costs (energy consumption and system maintenance) pose significant financial hurdles for Palestinian public schools. As a result, there is a conspicuous lack of such systems, leaving students to live in poor thermal conditions. The second reason is that the prevailing approach in many public schools tends to neglect the incorporation of passive design principles. These principles offer practical alternatives for improving indoor thermal comfort without relying solely on HVAC systems. When schools fail to take advantage of passive design strategies that take advantage of natural elements such as optimal building orientation, shading, and insulation, they inadvertently increase their reliance on HVAC solutions.

5.4.2 Lighting and Acoustics Comfort

The assessment of comfortable lighting in public schools presents a multi-faceted picture: first, a significant proportion of students are satisfied with the level of lighting in their classrooms. Figure 5.30 shows that about 86% of students rate the lighting as good and acceptable, indicating a positive response to the given lighting. Fluorescent tubes, especially T8 or T5 tubes, are the most common choice in lighting technology in public schools. It is encouraging to see the gradual conversion to more energy efficient LED tube lighting. However, this is not a planned and proactive upgrade, but a conversion caused primarily by the need to replace defective lamps. However, glare control is a major concern. Glare index standards are not consistently followed in classroom lighting design, resulting in less than optimal lamp selection. This can affect students' visual comfort and overall well-being.

Although students rated visual comfort as good, the level of lighting and visual comfort in public schools is almost poor and inadequate. One of the main reasons for this is the lack of consideration of ergonomic lighting standards in school design. Without clear instructions, emphasis on recessed lighting can be neglected, leading to suboptimal lighting results. The problem is exacerbated by the fact that design firms often rely on rules of thumb when planning school lighting. These sweeping generalizations lack the necessary accuracy and individualized approach, and they often ignore the needs and preferences of the population.

As a result, this approach has the potential to reduce the overall comfort level of lighting in schools.

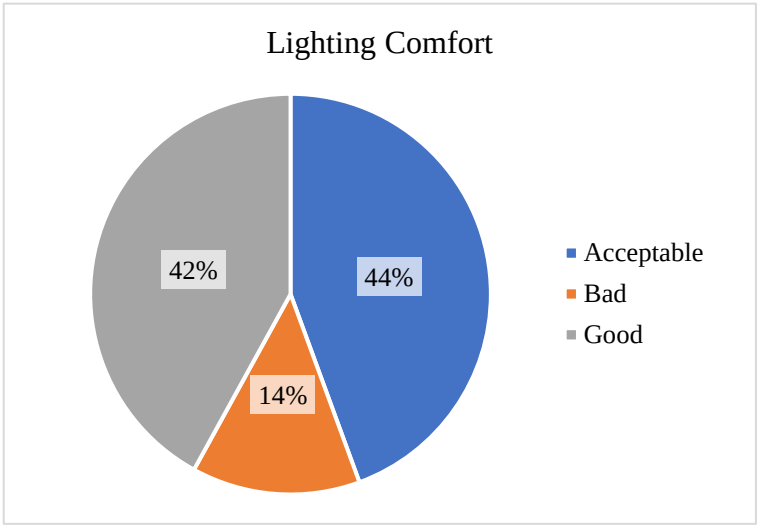

Figure 5.30. The lighting comfort level in the classrooms based on students' opinions.

Acoustical comfort varies greatly from school to school and depends largely on factors such as interior design, materials used, and how the space is used. In general, about half of the students are satisfied with the acoustics both in the classroom and in the hallways and courtyards of the school, see Figure 5.31. While the other half have problems with the acoustic environment. The inadequate acoustic comfort is mainly due to the fact that mandatory acoustic requirements were not established in the original design phase for public schools. In addition, school furnishings often use traditional building materials that further increase indoor noise levels. These materials often have poor sound absorption properties, which increases the reverberation of sound and creates an unpleasant acoustical environment. In addition, efforts to reduce outside noise pollution, especially from road traffic, are often found to be inadequate. As a result, the Ministry of Education has issued a regulation requiring the use of sound-insulating plaster in the ceilings of newly constructed schools. This scenario underscores the need for holistic acoustics to ensure a pleasant and harmonious listening experience in educational buildings.

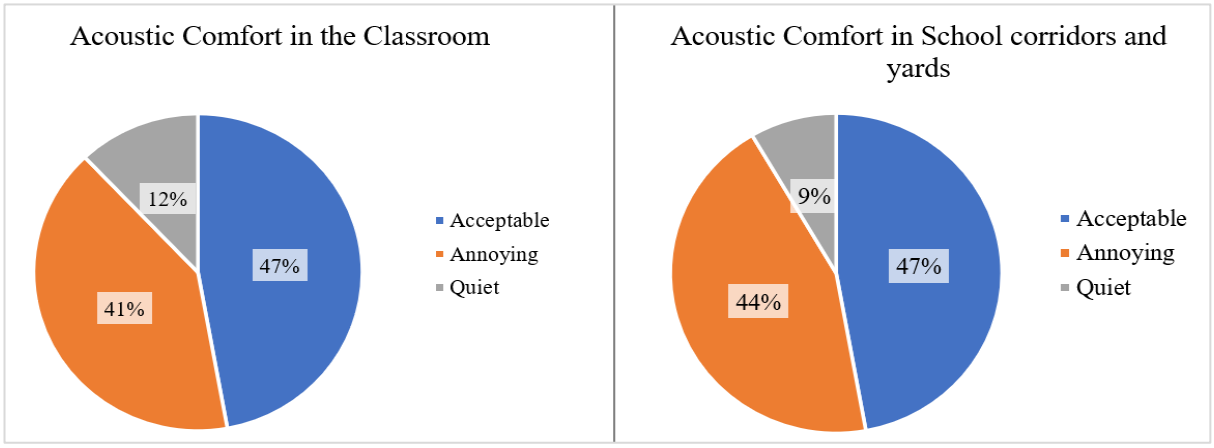

Figure 5.31. The Acoustics comfort level in the classrooms and school's corridors and yards based on students' opinions.

5.4.3 Indoor Air Quality

Two-thirds of students report noticing either sporadic or constant unpleasant odors in their classes, highlighting the problem of unpleasant odors in classrooms at school, as shown in Figure 5.32. In addition, a smaller percentage, about 45% of students, notice similar unpleasant odors in their labs. This underscores the importance of thoroughly addressing odor issues to create a more pleasant and conducive environment for effective learning. In addition, a large majority of students - more than two-thirds - experience some sluggishness in their classes, whether on a regular or occasional basis. This indicates high levels of carbon dioxide in the air in classrooms because they are not adequately ventilated. We can say that the significant air quality problems in Palestine's public schools are mainly due to the lack of ventilation systems in individual classrooms. The air quality in the laboratories is slightly better than in the classrooms, but this is due to the lower occupancy rate and slightly increased ventilation. However, in the winter, the lack of heating systems causes students to close their windows, which interrupts natural circulation and exacerbates air quality problems.

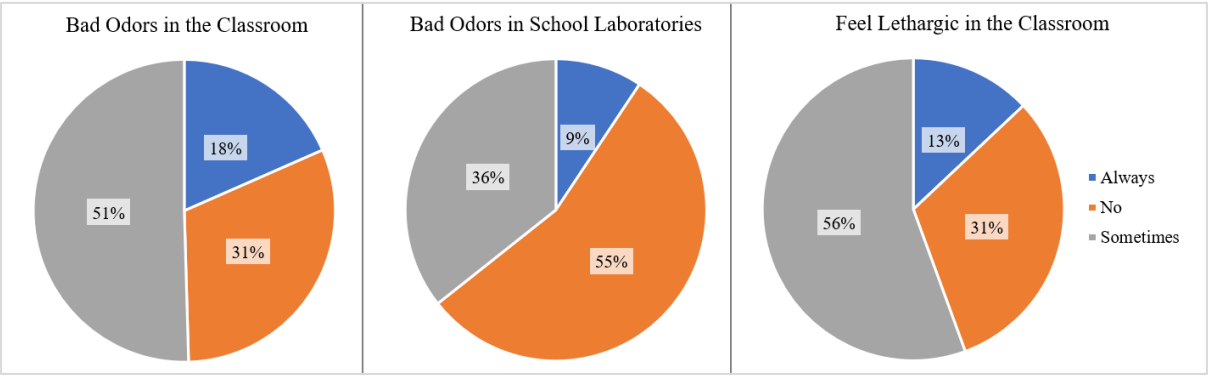

Figure 5.32. The air quality in the classrooms and schools' laboratories based on students' opinions.

5.4.4 Ergonomic Comfort

1. **Safety and Security**

Students' opinions about how safe they feel in the school environment are broad, see Figure 5.33. More than 60% of respondents, the vast majority, expressed a strong sense of safety and felt reassured by security measures supported by the presence of fences and gates surrounding most schools. These physical barriers effectively repel outside attackers and create an atmosphere that provides a sense of comfort and security. On the other hand, about a quarter of students reported feeling only partially safe, indicating a more subtle feeling that may be due to a variety of factors.

However, it is important to note that safety concerns vary from school to school. It should be noted that some schools, especially those with a long history, make their residents feel uncomfortable. This view can be influenced by a number of elements, including aging infrastructure, inadequate security measures, or inconsistent policies. In some cases, specific incidents, such as a small number of unruly students becoming violent on school grounds, may be associated with the feeling of fear. In addition, in some cases, schools are subject to

harassment by occupying forces, which affects the overall sense of safety among school occupants.

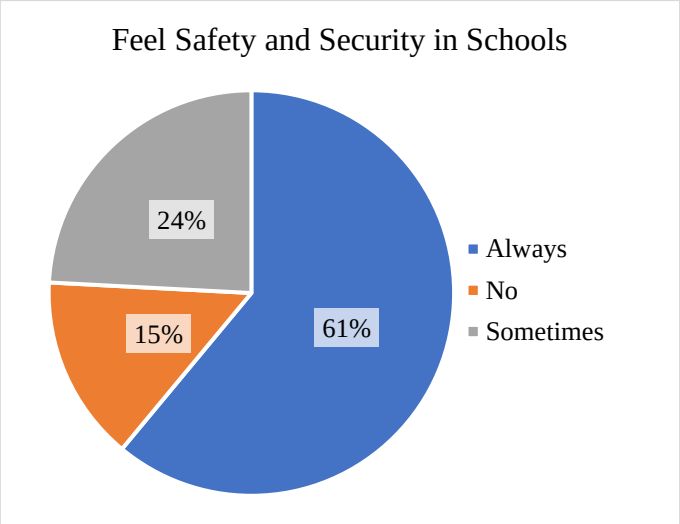

Figure 5.33. The proportion of feeling safety and security in schools based on students' opinions.

2. Colour Ergonomic Comfort

Students' opinions about color schemes and other visual elements in educational settings, including schools and classrooms, reflect a variety of perspectives. Figure 5.34 shows that over 80% of respondents indicated that they were satisfied with or even liked the decorative visual elements in their learning environment. This remarkable attitude is the result of educational institutions' meticulous attention to detail, as evidenced by their adherence to color standards established by the Department of Education. These regulations specify color schemes for interior design and classrooms that are carefully matched to the age of the students. This careful work helps to make the environment fun and visually appealing, which in turn contributes to the overall satisfaction of most students.

However, less than 20% of students expressed dissatisfaction with the esthetic features of their school buildings, finding them unattractive or distracting. This dissatisfaction may be due in part to the lack of innovative design and esthetics in some school buildings. Under these circumstances, the lack of captivating esthetics may lead to lower satisfaction with the colors and motifs already present. Another factor affecting student satisfaction with colors is individual perceptions and preferences. Appreciation of colors varies greatly from student to student, leading to differences in student satisfaction.

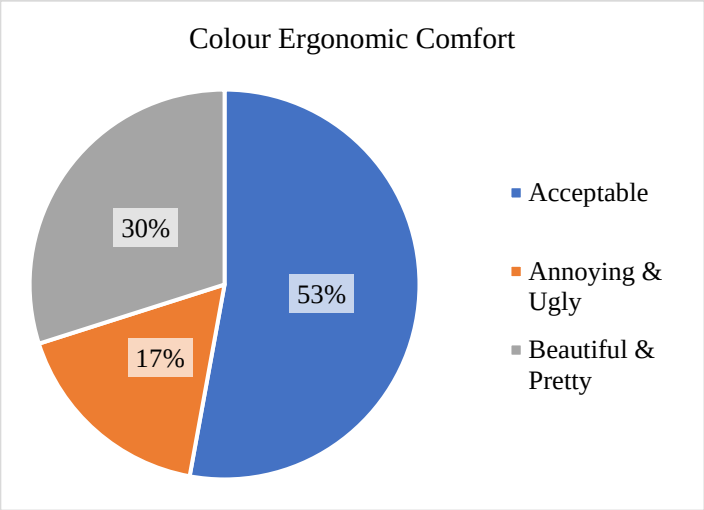

Figure 5.34. The proportion of colour ergonomic comfort in schools based on students' opinions.

3. Furniture Ergonomic Comfort

An analysis of classroom furniture shows that students have different views, see Figure 5.35. The ergonomic characteristics of classroom furniture were recognized or expressed with satisfaction by more than 70% of the students who participated in the survey. The majority of them think that the furniture is inviting and perfect for their needs. On the other hand, almost 30% of students expressed dissatisfaction, citing problems with comfort and esthetics. While some students find the chairs uncomfortable, others find them unsightly. A major reason for the unfavorable rating is the irregular maintenance in some educational institutions. The quality and usability of furniture deteriorates when basic maintenance is neglected, which affects the overall esthetics of the learning environment. In addition, financial constraints make it difficult to replace furniture in a timely manner. Some students experience more poor quality during their education because the wear and tear and inconvenience caused by outdated furniture is not addressed in a timely manner.

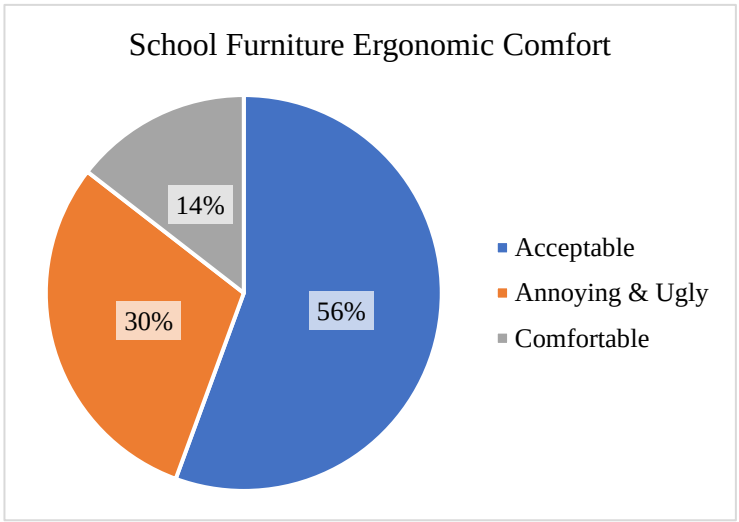

Figure 5.35. The proportion of school furniture ergonomic comfort in schools based on students' opinions.

4. Ergonomic Comfort in School Yards

The study of the ergonomic characteristics of schoolyards provides important information about students' comfort and discomfort. About 27% of students say they are comfortable in their schoolyards, while the majority say they are uncomfortable there to varying degrees, from occasional to constant discomfort, as shown in Figure 5.36. This difference in well-being can be explained by several factors. First, the lack of regulations as they apply to green building in schoolyards. The lack of uniform standards can lead to poor planning and design, which in turn can lead to poor environmental conditions in the schoolyard. Second, schoolyards often lack shaded areas, green space, and appropriate seating, which negatively impacts student well-being. During periods of higher temperatures, the lack of green space and sheltered areas becomes even more apparent, limiting opportunities for outdoor recreation and activities. In addition, the type of materials used to construct the schoolyard has a major impact. For example, the use of certain materials, such as asphalt, can exacerbate the heat island effect and increase student discomfort in these areas.

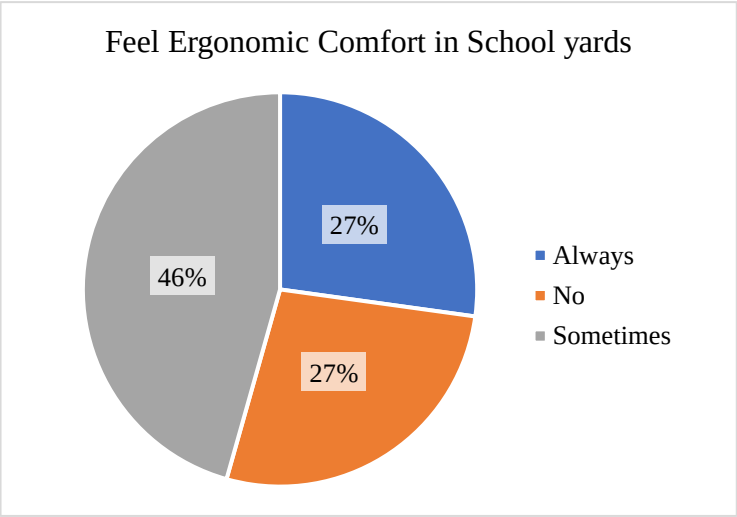

Figure 5.36. The proportion of ergonomic comfort in school yards based on students' opinions.

A comprehensive analysis of the determinants of the quality of the indoor environment in schools reveals a complex set of student experiences. Many students are uncomfortable due to inadequate heating and cooling systems, making thermal comfort a complex issue. Further complicating the issue is the lack of passive design principles that impact indoor comfort. Opinions are divided on lighting comfort. While many students are satisfied with current systems, flares and outdated materials prevent the best lighting conditions. Acoustical comfort in schools varies, depending on factors such as design, materials, and occupancy patterns. Although many children feel safe and secure in their schools, people feel uncomfortable in older buildings. Satisfaction with esthetic and ergonomic aspects such as colors, furniture, and outdoor spaces varies widely and is highly dependent on maintenance practices and design. All these observations highlight the importance of specialized interventions that include ergonomic promotions, modern amenities, and a commitment to setting standards to improve student well-being and learning experiences.

5.5 Discussion and Recommendation

This section offers a range of recommendations to improve sustainability in public schools, informed by the knowledge gained from the comprehensive sustainability index assessment and the findings previously mentioned.

5.5.1 Environmental Aspect

We propose the following environmental discussion and recommendations to improve the sustainability within of public schools:

1. **Energy Consumption**

The results show that energy consumption is consistently low in all the Palestinian public schools studied, with an average consumption of 10.17 kWh/m^2, albeit with some differences between schools. However, this observation does not necessarily indicate high energy efficiency. Rather, this can be attributed primarily to the lack of heating and cooling systems in these educational institutions. In addition, few use thermal insulation and shading systems on the walls, which reduces thermal comfort in the school buildings. Despite Tulkarm's sunny climate, which favors the use of solar energy, only one-fifth of schools use solar panels to generate energy. To address these challenges, we recommend the following:

a. Implement energy efficient building regulations: it is imperative that all school buildings in Palestine comply with energy efficient building regulations. This step is key to significantly improving the overall sustainability rating of these schools. Energy efficiency can be significantly improved by incorporating passive design strategies such as thermal insulation, orientation, shading, etc. This step is key to significantly improving the overall sustainability rating of these schools.
b. Consider HVAC systems: although HVAC systems typically consume more energy, they are essential to improving indoor thermal comfort in schools. Therefore, any simulation or analysis of a school's energy use must assume the presence of an HVAC system in order to accurately assess a school's energy performance.
c. Renewable energy integration: Palestine's sunny weather and large school footprints must be leveraged to improve school sustainability through the integration of clean energy generation technologies, such as photovoltaic systems.

Water Efficiency

While water use in individual schools varies by school location, student age, and gender, the quality and quantity of water provided to schools generally meets satisfactory standards. On the other hand, only 15% of schools used rainwater harvesting tanks for cleaning and irrigation purposes. Therefore, we recommend:

a. Use of Water-Saving Facilities: To reduce water wastage and enhance water use efficiency, it is highly recommended to install water-saving taps and toilets in schools.
b. Focus on Rainwater Harvesting: use rainwater harvesting for non-potable uses such as irrigation, toilet flushing, and cleaning. It is an effective tool for increasing water use efficiency and the overall sustainability of public schools.

2. Site Development

Many schools lack basic indicators of site development such as shaded outdoor areas, green spaces, and surfaces with high Solar Reflective Indexes (SRI). Furthermore, waste segregation practices were absent in all the schools surveyed. Thus, several measures can be taken to enhance the site sustainability in these educational institutions, namely:

a. Provision of Outdoor Shaded Areas: A significant percentage of the outdoor areas of schools should be equipped with fixed or mobile shading structures to improve outdoor comfort and reduce heat stress.
b. Mandatory Inclusion of Green Areas: Incorporating green and landscaped areas should be mandated in school design to promote a more sustainable and aesthetic environment.
c. Adoption of Cool Pavement and High SRI Surfaces: Utilizing cool pavement and surfaces with a high Solar Reflective Index is crucial for enhancing site sustainability and improve thermal comfort in schools.
d. Integration of waste segregation: Waste segregation should be included in public schools as a practical example for students about waste management and treatment.

3. Indoor Environmental Quality

One of the most important findings of this chapter is the comprehensive analysis of factors affecting the quality of indoor environments in schools based on the experiences of 331 students. Many students are uncomfortable due to inadequate heating and cooling systems, making thermal comfort a complex problem. Further complicating the issue is the lack of passive design principles that impact indoor comfort. There are conflicting opinions about lighting comfort. While many students are satisfied with current systems, glare problems and outdated materials prevent the best lighting conditions from being created. Acoustical comfort in schools varies by design, materials, and occupancy patterns. Student opinions indicate high levels of carbon dioxide in the air in classrooms because they are not adequately ventilated. Satisfaction with aesthetic and ergonomic aspects such as colors, furniture, and outdoor spaces varies widely and is highly dependent on maintenance procedures and design. All of these observations underscore the following recommendations:

a. Thermal Comfort Solutions: Effective insulation, shading, and passive principles must be implemented to maintain pleasant indoor temperatures year-round and regulate natural light and heat exposure.
b. Visual and Acoustics Comfort Solutions: Transition to energy-efficient lamps (like LED) across classrooms to improve lighting efficiency. Ensure visual comfort by optimizing window to wall ratios to optimize daylighting and strictly adhering to glare index standards during lighting design. Improving acoustical comfort by incorporating sound-absorbing panels in classrooms and corridors to reduce noise levels.
c. Indoor Air Quality Enhancement: Employing efficient ventilation systems to ensure optimal indoor air quality, fostering students' health, focus, and well-being. Meeting heating needs through alternative strategies like earth tubes or solar chimneys, maintaining thermal comfort without compromising ventilation.

d. Ergonomic Comfort Solutions: Establishing annual maintenance schedules to support furniture and colour quality, to meet ergonomic needs. In addition to taking the opinion of students when making changes to suit their desire and aspirations

5.5.2 Economic Aspect

Most schools share a similar approach to financial management, because they all are government-funded institutions operating under similar strategies and systems. However, the results indicate that there are differences in maintenance costs between different schools, with primary schools generally incurring higher costs than secondary schools. In addition, the income generated from other activities related to the school is very low. These results lead to the following recommendations:

a. Sustainable Materials Selection: Adopting sustainable building materials and local materials, especially in primary schools, is essential to reduce maintenance costs and raise schools' overall sustainability rating.
b. Multi-Activity Attraction: Sustainable schools have the potential to attract a wide range of activities, funding, and support from local organizations and private companies. It is central to increasing sources of income and enhancing economic sustainability.

5.5.3 Social Aspect

Socially, the primary goal of the Palestinian education sector is to provide equal access to education for all. This commitment is reflected in the inclusion of low-income students in all selected schools. In addition, 57% of schools have students with special needs, ensuring inclusion in education. However, the inadequate infrastructure to meet the needs of this group needs to be addressed, which affects their comfort in the school environment. The secondary goal focuses on increasing the quality of education and improving learning outcomes. The quality of education can be assessed through indicators such as success rates, attendance, and dropout rates. With an average success rate of 94%, an attendance rate of 92.60%, and an average dropout rate of 1.25%, Palestinian schools demonstrate a high quality of education. However, the teaching method lacks sustainability and relies on memorization instead of diverse experiences and activities that will raise an aware generation equipped to face the challenges. In addition, data shows that only 19% of schools have parking for school staff, with an average of 5.7%. However, decision-making in public schools tends to be centralized in the Ministry of Education, resulting in limited stakeholder engagement, particularly with students. This goes against the core of a sustainable education system, which aims to empower students with decision-making authority and responsibility. Below are a number of social recommendations:

a. Improving the Inclusivity and Accessibility: Creating inclusive learning environments to support diversity and develop a feeling of community among students from all backgrounds. In addition to ensuring that sustainable initiatives and infrastructure improvements serve all students, especially those with disabilities or special needs, in new and existing school buildings.

b. Student Involvement and Empowerment: Encourage student-led sustainability initiatives, such as eco-clubs or green teams, to foster a sense of ownership and responsibility for maintaining sustainable practices. It serves as a platform for students to express their opinion and participate in decision-making.
c. Improving Indoor Quality: Designers and stakeholders must prioritize better ventilation and indoor air quality, as these factors are associated with improved student health, reduced sick leaves, and increased student productivity and success rates.

5.5.4 Policy Aspect

Developing effective policies is critical to driving systemic change and ensuring the long-term sustainability of public schools in Palestine. The following are recommendations for policymakers and decision-makers:

a. Sustainability Integration in Education Curricula: The incorporation of sustainability principles into educational curricula and policy framework at all levels is crucial. This integration helps achieve the mentioned improvements by enhancing students' awareness across their academic studies.
b. Sustainability Building Standards and Code: Establishing and implementing sustainability and green building standards for all new school construction and major renovations is an essential step. In addition, it is important to provide incentives or financial grants to schools that adhere to green building guidelines and achieve high sustainability standards.
c. Assessment and Monitoring Methodology: Establishing a tool for collecting and evaluating data on key sustainability metrics in schools is essential to ensuring long-term sustainability. Our framework is considered as the first sustainability building assessment tool for schools in Palestine, which helps in this step.
d. Capacity Building and Training: Develop training programs for teachers, administrators, and school staff to build their capacities in implementing and promoting sustainable practices.

To guide meaningful change, these brief recommendations include policies for schools and policymakers alike. For schools, strategies include optimal use of resources, student engagement, and diverse amenities. For policy makers and stakeholders, these suggestions revolve around curriculum integration, enforcement of standards, inclusive partnerships, and robust oversight mechanisms. Collectively, these recommendations fuel a flexible and environmentally conscious education landscape.

5.6 Conclusion

In this chapter, a comprehensive assessment of the sustainability of Palestinian schools was conducted. The results show that there is an urgent need to improve the sustainability of the schools. On the environmental level, the schools had low energy consumption rates due to the absence of HVAC systems. In addition, thermal insulation and shading systems were used very little in the schools. Although the quality and quantity of water was generally satisfactory, rainwater harvesting was underutilized. The lack of shaded outdoor areas, green spaces, and waste separation affected the development of the site. Students' opinions showed that thermal comfort, lighting, acoustics, and indoor air quality were perceived differently. Economically, the schools have similar financial management strategies, but we found differences in maintenance costs and income generation. From a social perspective, inclusion was evident with the enrollment of low-income students and people with special needs, but there is still a lack of adapted infrastructure. Centralization of decision-making hindered student participation, which affected the role of students in decision making.

The sustainability index varies between 0.229 and 0.479, with an average of 0.343, measuring the extent to which Palestinian schools adopt sustainable practices. The highest sustainability index reached 0.855, while the worst dropped to 0.082. The sustainability performance of most schools (96%) was below this middle range between the ideal and worst sustainability scenarios. However, all schools performed better than the worst case. This indicates that progress toward sustainability has been made in schools, but there is still room for improvement. The results underscored the importance of social factors to school sustainability, particularly social inclusion.

The research led to some recommendations for a comprehensive roadmap for sustainability in Palestinian public schools. (i) Energy: adopt energy efficient building codes, integrate HVAC systems, and use renewable energy sources. (ii) For water: improve water conservation and rainwater harvesting. (iii) For site development: add shaded areas, incorporate green space, use cool sidewalks, and implement waste separation practices, (iv) For social development: promote accessibility and equity, increase student participation, and improve internal quality. (v) From a policy perspective: integrate sustainability into school curricula, establish building standards, use assessment tools, and provide capacity building initiatives.

General Conclusion

Achievement of Research Objectives

The purpose of this study was to provide an innovative framework for assessing the sustainability of public buildings and schools in Palestine. Unlike many current tools that focus on the environment, the proposed framework covers a broader spectrum, including social and economic dimensions. While other assessment tools are tailored to specific environments, this framework can also be adapted to educational institutions, making it more versatile and valuable.

In order to achieve the research objective, the applied methodology started with an extensive literature review, including the analysis of relevant research in the field and the global sustainability assessment tools such as BREEAM, LEED and SBTool. Subsequently, Palestine was selected as a case study due to its complex political conditions (under occupation), environmental challenges (such as limited resources and geographic and climatic diversity), and socioeconomic conditions (such as poverty, unemployment, and inadequate municipal services). After analyzing the Palestinian context, a comprehensive framework for assessing the sustainability of public buildings was proposed, which was then adapted to the school system. Based on the selected indicators and their weights, an assessment of the sustainability of public schools in Tulkarm and Nablus was conducted, including data collection through questionnaires submitted to school principals and communities. The collected data was analyzed and recommendations were made to improve sustainability in these schools.

This research confirmed the fulfillment of its main objective as follows. For public buildings, the framework included 25 indicators covering six categories of sustainability: energy efficiency, water efficiency, green city, indoor environmental quality, social aspects, and economic aspects. Expert opinions emphasized the importance of energy efficiency and indoor environmental quality as priority aspects for public buildings. For schools, the framework included 35 indicators covering 11 sustainability categories, namely energy efficiency, water efficiency, indoor environmental quality, site development (environmental category), annual operating costs, impact on local economy (economic category), social equity, health and comfort, social cohesion, accessibility, and teaching quality (social category). According to the experts, the social category is more important for public schools with a weighting of 46.2%, followed by the environmental category with a weighting of 36.5%, while the economic dimension is less important with a weighting of 17.4%.

Applying the proposed framework to a set of schools revealed important findings. On the environmental level, the schools had low energy consumption rates due to the absence of HVAC systems. The use of thermal insulation and shading systems in schools is reduced. Although the quality and quantity of water were generally satisfactory, rainwater harvesting was underutilized. The lack of shaded outdoor areas, green spaces and waste separation affected the development of the site. The quality of the indoor environment was evaluated based on students' opinions, so scores for thermal comfort, lighting, acoustics, and indoor air quality varied according to students' perceptions. Economically, the schools have similar

financial management strategies, but the differences in maintenance costs and income generation are significant. From a social perspective, inclusion has been evident through enrollment of low-income students and those with special needs, but infrastructure for these categories remains problematic. The centralization of decision-making hindered student participation and compromised their role in decision-making.

Based on the Sustainability Index scores, the level of sustainability is low in all the schools studied. Consequently, schools need to make significant progress in the environmental, economic, and social areas. Girls' schools have a slight edge over boys' schools due to their apparent efforts in social inclusion, although environmental performance is similar. Similarly, elementary schools outperform secondary schools in terms of overall sustainability, although the latter have a clear advantage in the environmental domain. This underscores the importance of social indicators in influencing and determining the overall sustainability of schools, particularly social inclusion.

The study makes a number of recommendations to improve sustainability in Palestinian schools. These include the introduction of energy-efficient building codes, green building principles, the use of renewable energy sources, rainwater harvesting, and the introduction of waste separation. Promoting inclusion, increasing student engagement, and improving indoor space quality are all important for social improvement.

Limitations and Future Research

The application of this study was limited to 54 schools in Tulkarm and Nablus in the West Bank. This limitation is due to the great difficulty in data collection. Nevertheless, this study paves the way for future research. First, expanding the geographic scope of the current study may allow for a broader understanding by including schools from different regions, including the Gaza Strip. Second, the framework needs to be improved by expanding the expert panel to include experts with social and economic specialties to make the framework more comprehensive. In addition, examining the long-term impact of sustainability practices in schools would provide a holistic perspective beyond immediate outcomes. Due to the continuous evolution of sustainability practices and frameworks, there is also an opportunity to improve and adapt the assessment framework to align with new standards and emerging global trends. This could include working with international experts and institutions to ensure that the framework remains relevant and practical. Finally, further investigation into the mechanisms of student engagement and participation in sustainability programs in schools could provide insightful data.

The lessons learned from this study provide a comprehensive overview of the challenges and opportunities for a more sustainable future. While this study has its limitations, it is an important starting point for further investigation and innovation. The path to sustainability is a continuous process of learning, adaptation, and collaboration.

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Appendix

Appendix 3

Table 3.1. The first section in the public building questionnaire.

Questionnaire for the Sustainability of Public Buildings in Palestine	
Section One: Expert Profile Questions	
Gender	○ Male
	○ Female
Education Level	○ Bachelor
	○ Master
	○ PhD
Specialization	○ Architecture
	○ Civil Engineering
	○ Economic
	○ Management
	○ Other
Working Position	---- Short answer text
Working Sector	Public Sector
	Privet Sector

Table 3.2. The second section in the public building questionnaire.

Questionnaire for the Sustainability of Public Buildings in Palestine					
Section Two: Sustainable Indicators Rating					
Note: As an expert, you should rate the following indicators based on "How do you see the importance of each of the following items to achieve sustainability requirements for public buildings in Palestine".					
Rating Scale	**1 (Completely unimportant)**	**2 (Unimportant)**	**3 (Neutral)**	**4 (Important)**	**5 (Completely important)**
Category One: Energy Efficiency					
Total Energy Consumption	○	○	○	○	○
Renewable Energy Production	○	○	○	○	○
Cooling Energy Consumption	○	○	○	○	○
Heating Energy Consumption	○	○	○	○	○
Hot water Energy Consumption	○	○	○	○	○

Category Two: Water Efficiency					
Total Water Consumption	○	○	○	○	○
Hot Water Consumption	○	○	○	○	○
Irrigation Water Consumption	○	○	○	○	○
Quantity of Rainwater Harvesting	○	○	○	○	○
Recycled Grey Water	○	○	○	○	○
Connection to Public Sewage	○	○	○	○	○
Category Three: Green Aspect					
The Green Area Percentage	○	○	○	○	○
Solid Waste Production	○	○	○	○	○
Green House Gas Emission	○	○	○	○	○
Category Four: Indoor Comfort					
Temperature Comfort	○	○	○	○	○
Humidity Comfort	○	○	○	○	○
Indoor Noise Pollution	○	○	○	○	○
Indoor Air Quality	○	○	○	○	○
Safety and Security	○	○	○	○	○
Category Five: Social Aspects					
Public Transportation Service	○	○	○	○	○
Social Activities	○	○	○	○	○
Hourly Occupation rate	○	○	○	○	○
Daily Occupation rate	○	○	○	○	○
Culture and Heritage	○	○	○	○	○
Category Six: Economic Aspects					

Operational Energy Expenses	○	○	○	○	○
Operational Water Expenses	○	○	○	○	○
Final question for Expert					
Other Indicators that you think is important and essential for sustainable public building in Palestine					

Table 3.3. The first part in the school field data questionnaire.

Questionnaire for the Sustainability of Public Schools in Palestine	
Section one: Expert Profile Questions	
Gender	○ Male
	○ Female
Education Level	○ Bachelor
	○ Master
	○ PhD
Specialization	○ Architecture
	○ Civil Engineering
	○ Economic
	○ Management
	○ Other
Working Sector	Public Sector
	Privet Sector
Experience in sustainability field	Less than 3 years
	3 - 10 years
	More than 10 years

Table 3.4. The second part in the school field data questionnaire.

Questionnaire for the Sustainability of Public Schools in Palestine					
Section Two: Environmentally Sustainable Indicators Rating					
Note: As an expert, you should rate the following indicators based on "How do you see the importance of each of the following items to achieve sustainability requirements for public buildings in Palestine".					
Rating Scale	**1 (Completely unimportant)**	**2 (Unimportant)**	**3 (Neutral)**	**4 (Important)**	**5 (Completely important)**
Category One: Energy Efficiency					
Heating Energy Consumption	○	○	○	○	○
Cooling Energy Consumption	○	○	○	○	○
Lighting	○	○	○	○	○

Energy Consumption					
Building Envelope Insulation	○	○	○	○	○
Renewable Energy Production	○	○	○	○	○
Category Two: Water Efficiency					
Total Water Consumption	○	○	○	○	○
Quantity of Rainwater Harvesting	○	○	○	○	○
Recycled Grey Water	○	○	○	○	○
Connection to Public Sewage	○	○	○	○	○
Category Three: Site Development					
Waste Management Strategies	○	○	○	○	○
Green Area	○	○	○	○	○
Heat Island Effect	○	○	○	○	○
Shading Area	○	○	○	○	○
Category Four: Indoor Quality					
Temperature Comfort	○	○	○	○	○
Visual Comfort	○	○	○	○	○
Acoustic Comfort	○	○	○	○	○
Indoor Air Quality	○	○	○	○	○
Safety and Security	○	○	○	○	○
Section Three: Social Sustainable Indicators Rating					
Category One: Social Equity					
Social Inclusion	○	○	○	○	○
Human Centred Design	○	○	○	○	○
Category Two: Health and Comfort					
Occupants Health	○	○	○	○	○
Ergonomic Comfort	○	○	○	○	○

Category Three: Social Inclusion					
Culture Value	○	○	○	○	○
Social Interaction	○	○	○	○	○
Category Four: Accessibility					
Access to Public Transportation	○	○	○	○	○
Access to Non-motorized Movement	○	○	○	○	○
Parking Area	○	○	○	○	○
Category Five: Teaching Quality					
Success Rate	○	○	○	○	○
Attendance Rate	○	○	○	○	○
Dropout Rate	○	○	○	○	○
Discipline Referrals	○	○	○	○	○
Section Four: Economical Sustainable Indicators Rating					
Category One: Annual Operating Cost					
Operational Energy Expenses	○	○	○	○	○
Operational Water Expenses	○	○	○	○	○
Maintenance Cost	○	○	○	○	○
Category Two: Influence on Local Economy					
Creating Jobs/ Employment	○	○	○	○	○
Production Activity	○	○	○	○	○

Table 3.5. The first section in the school field questionnaire.

No.	School field Questions	Answers		
1.	School Name	…….. (Text)		
2.	Gender	□ Girls	□ Boys	□ Both
3.	Grade	□ Secondary	□ Primary (lower)	□ Primary (upper)
4.	Location	□ City	□ Town	□ Village
5.	No. of Students	…….. (Number)		
6.	No. of Teachers	…….. (Number)		
7.	No. of Administration Staff	…….. (Number)		
8.	Establishment Year	…….. (Number)		
9.	Funding Body	□ Government	□ Donor Countries	□ Individual Donations

10.	School Building Area	…….. (Number/ m^2)
11.	Playground Area	…….. (Number/ m^2)

Table 3.6. The environmental questions in the second section of school field questionnaire.

	No.	Environmental Questions	Answers	
Energy-Related Items	**1.**	Are there PV panels in the school building?	□ Yes	□ No
	2.	If yes, how much the capacity of these panels	…….. (Number/kWh)	
	3.	Is there insulation in school building envelope?	□ Yes	□ No
	4.	Is there shading device on south elevation?	□ Yes	□ No
	5.	Is there shading device on east elevation?	□ Yes	□ No
Water and Sanitation	**6.**	Is there rainwater tank in school?	□ Yes	□ No
	7.	If yes, how much is its size?	…….. (Number/ m^3)	
	8.	The sanitation system is connected directly with	□ Public Sewage	□ Septic Tank
	9.	The efficiency of the sanitation system is	□ Normal	□ Perfect
Site Development	**10.**	The total area of the school site	…….. (Number/ m^2)	
	11.	The total green area in school site	…….. (Number/ m^2)	
	12.	The total shading area in the school site	…….. (Number/ m^2)	
	13.	The outside play area and yards are paved by using	□ Asphalt	□ Low SRI material
	14.	Is there a waste separation in school?	□ Yes	□ No

Table 3.7. The social questions in the third section of the school field questionnaire

No.	Social Questions	Answers
1.	The number of low-income students	…….. (Number)
2.	The number of disabled students	…….. (Number)
3.	The percentage of the teachers' participation in decision making	…….. (%)
4.	The percentage of the parents' participation in decision making	…….. (%)
5.	The percentage of the student's participation in decision making	…….. (%)
6.	Student attendance rate	…….. (%)
7.	Student sick absence rate	…….. (%)
8.	Student success rate	…….. (%)
9.	Student dropout rate	…….. (%)
10.	Parking Area	…….. (Number/ m^2)
11.	Access to Public Transportation	…….. (Number/ m^2)
12.	Ease of access to the school	□ Easy □ Not Easy

Table 3.8. The economic questions in the fourth section of school field questionnaire.

No.	Economic Questions	Answers

1.	The annual maintenance cost	…….. (Number/$)	
2.	The number of new teachers	…….. (Number)	
3.	The number of new staff	…….. (Number)	
4.	Is the school space used for social activities outside the official working hours?	□ Yes	□ No
5.	If yes, how much is the financial return	…….. (Number/$))	

Table 3.9. The questions used to evaluate the school indoor quality according to students ' opinions.

School Indoor Quality Questionnaire			
Questions	Ranking		
	1	2	3
1. In summer, how do you feel about the temperature in the classroom?	□ Moderate	□ Hot	□ Very Hot
2. In winter, how do you feel about the temperature in the classroom?	□ Moderate	□ Cold	□ Very Cold
3. On cold days, the heating devices are used in the classroom?	□ No - Never	□ Sometimes	□ Yes - Always
4. How would you describe your winter clothes?	□ Light	□ Moderate	□ Heavy
5. How would you describe the lighting level in the classroom?	□ Bad	□ Acceptable	□ Good
6. How would you describe the noise in the classroom?	□ Annoying	□ Acceptable	□ Quiet
7. How would you describe the noise in the school corridors and yards?	□ Annoying	□ Acceptable	□ Quiet
8. Do you feel lethargic in the classroom (Air quality)?	□ No - Never	□ Sometimes	□ Yes - Always
9. Are there unpleasant and disturbing odors inside the classroom?	□ No - Never	□ Sometimes	□ Yes - Always
10. Are there unpleasant and disturbing odors inside school laboratories?	□ No - Never	□ Sometimes	□ Yes - Always
11. How to find the colours of the classes and the school in general?	□ Annoying & Ugly	□ Acceptable	□ Beautiful & Pretty
12. How to find chairs, tables, and school furniture?	□ Annoying & Ugly	□ Acceptable	□ Comfortable & Pretty
13. Do you feel comfortable in the school yards?	□ No - Never	□ Sometimes	□ Yes - Always
14. Do you feel safe inside the school?	□ No - Never	□ Sometimes	□ Yes - Always

Appendix 4

Table 4.1. List of indicators used by LEED for Schools

LEED v4 for Operations & Maintenance: Schools		
Location and Transportation		**15**
Credit	Alternative Transportation	15
Sustainable Sites		**10**
Prereq 1	Site Management Policy	Required
Credit	Site Development-Protect or Restore Habitat	2
Credit	Rainwater Management	2
Credit	Heat Island Reduction	2
Credit	Light Pollution Reduction	1
Credit	Site Management	1
Credit	Site Improvement Plan	1
Credit	Joint Use of Facilities	1
Water Efficiency		**12**
Prereq 1	Indoor Water Use Reduction	Required
Prereq 2	Building-Level Water Metering	Required
Credit	Outdoor Water Use Reduction	2
Credit	Indoor Water Use Reduction	5
Credit	Cooling Tower Water Use	3
Credit	Water Metering	2
Energy and Atmosphere		**38**
Prereq 1	Energy Efficiency Best Management Practices	Required
Prereq 2	Minimum Energy Performance	Required
Prereq 3	Building-Level Energy Metering	Required
Prereq 4	Fundamental Refrigerant Management	Required
Credit	Existing Building Commissioning— Analysis	2
Credit	Existing Building Commissioning—Implementation	2
Credit	Ongoing Commissioning	3
Credit	Optimize Energy Performance	20
Credit	Advanced Energy Metering	2
Credit	Demand Response	3
Credit	Renewable Energy and Carbon Offsets	5
Credit	Enhanced Refrigerant Management	1
Materials and Resources		**8**
Prereq 1	Ongoing Purchasing and Waste Policy	Required
Prereq 2	Facility Maintenance and Renovations Policy	Required

Credit	Purchasing- Ongoing	1
Credit	Purchasing- Lamps	1
Credit	Purchasing- Facility Management and Renovation	2
Credit	Solid Waste Management- Ongoing	2
Credit	Solid Waste Management- Facility Management and Renovation	2
Indoor Environmental Quality		17
Prereq 1	Minimum Indoor Air Quality Performance	Required
Prereq 2	Environmental Tobacco Smoke Control	Required
Prereq 3	Green Cleaning Policy	Required
Credit	Indoor Air Quality Management Program	2
Credit	Enhanced Indoor Air Quality Strategies	2
Credit	Thermal Comfort	1
Credit	Interior Lighting	2
Credit	Daylight and Quality Views	4
Credit	Green Cleaning- Custodial Effectiveness Assessment	1
Credit	Green Cleaning- Products and Materials	1
Credit	Green Cleaning- Equipment	1
Credit	Integrated Pest Management	2
Credit	Occupant Comfort Survey	1
Innovation		6
Credit	Innovation	5
Credit	LEED Accredited Professional	1
Regional Priority		4
Credit	Regional Priority: Specific Credit	1
Credit	Regional Priority: Specific Credit	1
Credit	Regional Priority: Specific Credit	1
Credit	Regional Priority: Specific Credit	1

Table 4.2. List of indicators used by BREEAM Education 2008.

BREEAM Education 2008	
Management	
Man 1	Commissioning
Man 2	Considerate Constructors
Man 3	Construction Site Impacts
Man 4	Building User Guide
Man 5	Site Investigation
Man 6	Consultation
Man 7	Shared facilities

Man 8	Security
Man 9	Publication of building information
Man 10	Development as a learning resource
Man 11	Ease of maintenance
Man 12	Life cycle costing
Health and Wellbeing	
Hea 1	Daylighting
Hea 2	View Out
Hea 3	Glare Control
Hea 4	High frequency lighting
Hea 5	Internal and external lighting levels
Hea 6	Lighting zones and controls
Hea 7	Potential for Natural Ventilation
Hea 8	Indoor Air Quality
Hea 9	Volatile Organic Compounds
Hea 10	Thermal Comfort
Hea 11	Thermal Zoning
Hea 12	Microbial Contamination
Hea 13	Acoustic Performance
Hea 16	Drinking Water
Hea 17	Specification of Laboratory Fume Cupboards
Energy	
Ene 1	Reduction of CO2 Emissions
Ene 2	Sub-metering of Substantial Energy Uses
Ene 3	Sub-metering of High Energy Load and Tenancy Areas
Ene 4	External Lighting
Ene 5	Low or Zero Carbon Technologies
Ene 6	Building fabric performance and avoidance of air infiltration
Ene 7	Cold Storage
Ene 8	Lifts
Ene 10	Free Cooling
Ene 11	Energy Efficient Fume Cupboards
Ene 12	Swimming pool ventilation and heat loss
Ene 13	Energy Efficient Laboratories
Ene 14	Energy Efficient IT Solutions
Transport	
Tra 1	Provision of Public Transport
Tra 2	Proximity to amenities
Tra 3	Cyclist Facilities
Tra 4	Pedestrian and Cyclist Safety
Tra 5	Travel Plan
Tra 6	Maximum Car Parking Capacity

Tra 7	Travel Information Point
Tra 8	Deliveries and Manoeuvring
Water	
Wat 1	Water Consumption
Wat 2	Water Meter
Wat 3	Major Leak Detection
Wat 4	Sanitary Supply Shut Off
Wat 5	Water Recycling
Wat 6	Irrigation Systems
Materials	
Mat 1	Materials Specification (Major Building Elements)
Mat 2	Hard Landscaping and Boundary Protection
Mat 3	Re-Use of Façade
Mat 4	Re-Use of Structure
Mat 5	Responsible Sourcing of Materials
Mat 6	Insulation
Mat 7	Designing for Robustness
Waste	
Wst 1	Construction Site Waste Management
Wst 2	Recycled Aggregates
Wst 3	Recyclable Waste Storage
Wst 4	Compactor / Baler
Wst 5	Composting
Land Use and Ecology	
LE 1	Reuse of Land
LE 2	Contaminated Land
LE 3	Ecological Value of Site and Protection of Ecological Features
LE 4	Mitigating Ecological Impact I5 Local biodiversity protection during construction
LE 5	Enhancing Site Ecology
LE 6	Long Term Impact on Biodiversity
LE 7	Consultation with Students and Staff
LE 8	Local Wildlife Partnership
Pollution	
Pol 1	Refrigerant GWP - Building Services
Pol 2	Preventing Refrigerant Leaks
Pol 3	Refrigerant GWP - Cold Storage
Pol 4	NOx emissions from heating source
Pol 5	Flood Risk No
Pol 6	Minimising Watercourse Pollution
Pol 7	Reduction of Nighttime Light Pollution
Pol 8	Noise Attenuation

Innovation	
Inn 1	Innovation

Table 4.3. List of indicators used by SBTool for K-12 Schools

SBTool for K-12 Schools	
A. Site Regeneration and Development, Urban Design, and Infrastructure	
A1. Site Regeneration and Development	
A1.1	Use of land with previously high ecological sensitivity or value
A1.2	Use of land with previously high agricultural value
A1.4	Use of previously contaminated land for development
A1.5	Remediation of contaminated soil, groundwater or surface water
A1.6	Shading of building(s) by deciduous trees
A1.7	Use of vegetation to provide ambient outdoor cooling
A1.8	Reducing irrigation requirements through the use of native plantings
A1.9	Provision of public open space(s)
A1.10	Provision and quality of children's play area(s)
A1.12	Provision and quality of bicycle pathways and parking
A1.13	Provision and quality of walkways for pedestrian use
A2. Urban Design	
A2.1	Development Density of Project
A2.2	Reducing need for commuting transport through provision of mixed uses
A2.3	Impact of orientation on the passive solar potential of building(s)
A2.4	Impact of site and building orientation on natural ventilation of building(s) during warm season
A2.5	Impact of site and building orientation on natural ventilation of building(s) during cold season(s)
A3. Project Infrastructure and Service	
A3.1	Provision of solid waste collection and sorting services
A3.2	Provision of split grey / potable water services
A3.3	Provision of surface water management system
A3.4	On-site treatment of rainwater, storm water and grey water
A3.5	On-site treatment of liquid sanitary waste
A3.6	Provision of on-site parking facilities for private vehicles
A3.7	Connectivity of roadways
A3.8	Provision of access roads and facilities for freight or delivery
A3.9	Provision and quality of exterior lighting
B. Energy and Resource Consumption	
B1. Total Life Cycle No-Renew Energy	

B1.1	Embodied non-renewable energy in original construction materials
B1.2	Consumption of non-renewable energy for all building operations
B2. Electrical peak	
B2.1	Electrical peak demand for building operations No
B3. Use of Materials	
B3.1	Degree of re-use of suitable existing structure(s) where available
B3.2	Material efficiency of structural and building envelope components
B3.3	Use of virgin non-renewable materials
B3.4	Use of finishing materials
B4. Use of potable water/ storm water/grey water	
B4.1	Use of water for occupant needs during operations
B4.2	Use of water for irrigation purposes
B4.3	Use of water for building systems
C. Environmental Loadings	
C1. Greenhouse Gas Emissions	
C1.1	GHG emissions from energy embodied in original construction materials
C1.2	GHG emissions from energy embodied in construction materials used for maintenance/replacement
C1.3	GHG emissions from primary energy used for all purposes in facility operations
C1.4	GHG emissions from primary energy used for project-related transport
C2. Other Atmospheric Emissions	
C2.1	Emissions of ozone-depleting substances during facility operations
C2.2	Emissions of acidifying emissions during facility operations
C2.3	Emissions leading to photo-oxidants during facility operations
C3. Solid and Liquid Wastes	
C3.1	Solid non-hazardous waste from facility operations sent off the site wastes
C3.2	Liquid effluents from building operations that are sent off the site
C4. Impacts on Project Site	
C4.1	Recharge of groundwater I5 Local biodiversity protection construction
C4.2	Changes in biodiversity on the site
C4.3	Adverse wind conditions at grade around tall buildings
C5. Other Local and Regional Impacts	
C5.1	Impact on access to daylight or solar energy potential of adjacent property
C5.2	Impact of building user population on peak load capacity of public transport system
C5.3	Impact of private vehicles used by building population on peak load capacity of local road system

C5.4	Potential for project operations to contaminate nearby bodies of water
C5.5	Cumulative (annual) thermal changes to lake water or sub-surface aquifers
C5.6	Contribution to heat Island effect from roofing, landscaping and paved areas
C5.7	Degree of atmospheric light pollution caused by project exterior lighting system
D. Indoor Environmental Quality	
D1. Indoor Air Quality and Ventilation	
D1.1	Pollutant migration between occupancies
D1.2	Mould concentration in indoor air
D1.3	Volatile organic compounds concentration in indoor air
D1.4	CO2 concentrations in indoor air
D1.5	Effectiveness of ventilation in naturally ventilated occupancies during Summer
D1.6	Effectiveness of ventilation in naturally ventilated occupancies during Spring/Fall
D1.7	Effectiveness of ventilation in naturally ventilated occupancies during Winter
D1.8	Air movement in mechanically ventilated occupancies
D1.9	Effectiveness of ventilation in mechanically ventilated occupancies
D2. Air Temp. Relative. Humidity	
D2.1	Appropriate air temperature and relative humidity in mechanically cooled occupancies
D2.2	Appropriate air temperature in naturally ventilated occupancies
D3. Daylighting and Illumination	
D3.1	Appropriate daylighting in primary occupancyareas
D3.2	Control of glare from day lighting.
D3.3	Appropriate illumination levels and quality of lighting
D4. Noise and Acoustics	
D4.1	Noise attenuation through the exterior
D4.2	Transmission of facility equipment noise to primary occupancies
D4.3	Noise attenuation between primary occupancy areas
D4.4	Appropriate acoustic performance within primary occupancy areas
E. Service Quality	
E1. Safety and Security	
E1.1	Occupant egress from tall buildings under emergency conditions
E1.2	Maintenance of core building functions during power outages
E1.3	Personal security for building users during normal operations.
E2. Functionality and efficiency	
E2.1	Provision of exterior access and unloading facilities for freight or delivery
E2.2	Efficiency of vertical transportation system.

E2.3	Spatial efficiency
E2.4	Volumetric efficiency
E3. Controllability	
E3.1	Effectiveness of facility management control system.
E3.2	Capability for partial operation of facility technical systems
E3.3	Degree of local control of lighting systems.
E3.4	Degree of personal control of technical systems by occupants
E4. Flexibility and Adaptability	
E4.1	Ability for building operator or tenant to modify facility technical systems
E4.2	Potential for horizontal or vertical extension of structure
E4.3	Adaptability constraints imposed by structure or floor-to-floor heights
E4.4	Adaptability constraints imposed by building envelope and technical systems
E4.5	Adaptability to future changes in type of energy supply
E5. Optimization and Maintenance of Operating Performance	
E5.1	Operating functionality and efficiency of key facility systems
E5.2	Adequacy of the building envelope for maintenance of long-term performance
E5.3	Durability of key materials
E5.4	Retention of as-built documentation
F. Social, Cultural and Perceptual Aspects	
F1. Social Aspects	
F1.1	Access for mobility-impaired persons on site and within the building
F1.2	Access to direct sunlight from living areas of dwelling units
F1.3	Visual privacy in principal areas of dwelling units
F1.4	Access to private open space from dwelling units
F2. Culture and Heritage	
F2.1	Impact of the design on existing streetscapes.
F2.1	Maintenance of the heritage value of the exterior of an existing facility
F3. Perceptual	
F3.1	Impact of tall structure(s) on existing view corridors
F3.2	Quality of views from tall structures
F3.3	Sway of tall buildings in high wind conditions
F3.4	Access to exterior views from interior
G. Cost and Economic Aspects	
G1. Cost and Economics	
G1.1	Construction cost
G1.2	Operating and maintenance cost
G1.3	Life-cycle cost

G1.4	Affordability of residential rental or cost levels

Table 4.4. List of indicators used by Palestinian Green Building Guideline (PGBG).

Palestinian Green Building Guidelines (PGBG)		
Site Sustainability		
•	Construction Activity Pollution Prevention	Required
1.1	Site Selection	4
1.2	Building Accessibility	3
1.3	Site Development	5
1.4	Outdoor Thermal Comfort Strategy	4
1.5	Urban heat Island Effect	4
1.6	Alternative Transportation	4
1.7	Storm Water Design	4
1.8	Light Pollution Reduction	2
Indoor Environment Quality		
•	Minimum IAQ Performance	Required
•	Smoking Control	Required
2.1	Healthy Ventilation Delivery	4
2.2	Material Emissions	4
2.3	Car Park Air Quality Management	2
2.4	Thermal Comfort & Controls	7
2.5	High Frequency Lighting	2
2.6	Daylight & Glare	3
2.7	View	2
2.8	Indoor Noise Pollution	3
2.9	Safe & Secure Environment	3
Energy Use efficiency		
•	Building energy systems planning	Required
•	Maximum energy efficiency with minimum energy consumption planning	Required
•	Planning to manage the building's cooling systems	Required
3.1	Achieving the best level of energy efficiency - insulation and shading	25
3.2	Renewable Energy	18
3.3	Efficiency of equipment and devices used in buildings	12
3.4	Smart Buildings	5
Water Use Efficiency		
•	Efficient use of water	Required
4.1	Rationalization of cold-water consumption (Water Consumption Tools)	16
4.2	Rationalizing the consumption of hot water	16

4.3	Efficient water harvest (collecting rainwater and condensed water)	4
4.4	Waste grey water recycling re-use	8
4.5	Water System Management, Monitoring, Metering and Control	6
Materials and Resources		
•	Construction and Operation Waste Management Program	Required
•	Hazardous Materials Elimination	Required
5.1	Non-Polluting Materials	3
5.2	Regional Materials	4
5.3	Recycled Materials	3
5.4	Rapidly Renewable Materials	2
5.5	Materials Reuse	2
5.6	Materials Durability	2
5.7	Building Reuse	2
5.8	Design for Flexibility and Disassembly	2
Innovation, New Technologies, and Building Integrated Design		
6.1	Innovation in Design	4
6.2	Integrated Design Approach	3
6.3	Use of modern technologies	3

Table 4.5. the Comparison among the proposed Palestinian School Framework and International Frameworks.

	Criteria	Palestinian Assessment Framework	LEED for School	BREEAM Education	SBTool for K12 school	PGBG
Environmental Aspect	**Energy Efficiency**	Heating Consumption	*	*	*	*
		Cooling Consumption	*	*	*	*
		Lighting Consumption	*	*	*	*
		Building Envelope	*	*	*	*
		Renewable Energy Production	*	*		*
	Water Efficiency	Total Water Consumption	*	*	*	*
		Supply Water Consumption	*	*	*	*
		Connection to Public Sewage		*		
	Indoor Quality	Thermal Comfort	*	*	*	*
		Visual Comfort	*	*	*	*

		Acoustic Comfort	*	*	*	*
		Indoor Air Quality	*	*	*	*
		Safety		*	*	*
	Site Development	Waste Management	*	*	*	*
		Green Area		*	*	*
		Heat Island Effect	*		*	*
		Shading Area			*	*
Social Aspect	**Social Equity**	Social Inclusion			*	
		Human Centred Design		*		
	Health and Comfort	Occupants Health				
		Ergonomic Comfort		*		
	Social Cohesion	Social Interaction				
		Cultural Value			*	
	Accessibility	Access to Public Transportation	*	*	*	*
		Access to Non-Motorized Mode of Movement	*	*	*	
		Parking Area	*	*	*	*
	Teaching Quality	Success Rates				
		Attendance Rates				
		Discipline Referrals				
		School Dropout				
Economic As.	**Annual Operating Costs**	Operational Expenses	*	*	*	*
	Impact on Local Economy	Creating Jobs/ Employment				
		Production Activity			*	

Table 4.6. The SWARA calculation steps of indicators' weights.,

Indicator	ID	Rank	Comparative importance of average value (sj)	Coefficient (Kj)	Recalculated weight (qj)	Indicator Weight (Wj)
Social Inclusion	P18	1		1	1	0.033
Indoor Air Quality	P12	2	0.02	1.02	0.98	0.032
Occupants Health	P20	3	0	1	0.98	0.032
Total Water Consumption	P6	4	0.05	1.05	0.93	0.031
Building Envelope Insulation	P4	5	0.01	1.01	0.92	0.031
Safety and Security	P13	6	0	1	0.92	0.031
Thermal Comfort	P9	7	0.01	1.01	0.92	0.030
Access to Public Transportation	P24	8	0	1	0.92	0.030
Heating Energy Consumption	P1	9	0.01	1.01	0.91	0.030
Green Areas	P15	10	0	1	0.91	0.030
Cultural Value	P23	11	0.02	1.02	0.89	0.029
Renewable Energy Production	P5	12	0.01	1.01	0.88	0.029
Visual Comfort	P10	13	0	1	0.88	0.029
Social Interaction	P22	14	0.01	1.01	0.87	0.029
Access to Non-motorized mode of movement	P25	15	0	1	0.87	0.029
Acoustic Comfort	P11	16	0.01	1.01	0.86	0.029
Shading Area	P17	17	0.01	1.01	0.85	0.028
Ergonomic Comfort	P21	18	0	1	0.85	0.028
Creating Jobs/ Employment	P35	19	0	1	0.85	0.028
Human Centred Design	P19	20	0.01	1.01	0.85	0.028
Attendance Rate	P28	21	0	1	0.85	0.028
Cooling Energy Consumption	P2	22	0.01	1.01	0.84	0.028
Waste Management Strategies	P14	23	0	1	0.84	0.028
Parking Area	P26	24	0	1	0.84	0.028
Maintenance Cost	P33	25	0	1	0.84	0.028
Success Rate	P27	26	0.01	1.01	0.83	0.027
Water Harvesting and Grey-water Recycling	P7	27	0.01	1.01	0.82	0.027
Operational Energy Expenses	P31	28	0.01	1.01	0.81	0.027
Connection to Public Sewage	P8	29	0.02	1.02	0.80	0.026
Operational Water Expenses	P32	30	0	1	0.80	0.026
Lighting Energy Consumption	P3	31	0.01	1.01	0.79	0.026
Social Activity	P36	32	0.01	1.01	0.78	0.026
School Dropout	P29	33	0.01	1.01	0.77	0.026
Discipline Referrals	P30	34	0	1	0.77	0.026
Heat Island Effect	P16	35	0.01	1.01	0.77	0.025

Appendix 5

Table 5.1. The respondents' results for the school general information.

School General Information											
No.	**Grade**	**Location Type**	**Gender**	**Students Number**	**Teachers Number**	**Staff Number**	**Establish-ment Year**	**Building Area (m^2)**	**Student Density (St/m^2)**	**Play Area (m^2)**	**Funding Body**
1	Secondary	Village	Both	201	20	4	2015	1,200	0.17	1,000	Donor Countries
2	Secondary	City	Both	550	56	17	1976	4,000	0.14	1,000	Donor Countries
3	Primary	City	Boys	433	21	5	1988	400	1.08	500	Government
4	Primary	Town	Girls	294	15	4	2012	1,000	0.29	1,000	Government
5	Primary	Town	Both	55	10	2	2008	690	0.08	400	Donor Countries
6	Primary	City	Girls	515	21	5	2002	1,514	0.34	730	Government
7	Primary	City	Girls	274	15	4	2004	1,100	0.25	1,150	Government
8	Secondary	Village	Boys	200	17	4	2016	2,730	0.07	250	Donor Countries
9	Primary	City	Girls	502	22	6	1950	920	0.55	850	Government
10	Primary	Village	Both	230	15	4	2006	1,200	0.19	800	Government /Individuals Donation
11	Secondary	Village	Boys	294	21	4	2000	1,740	0.17	600	Donor Countries
12	Primary	City	Girls	470	23	5	2019	750	0.63	880	Government
13	Secondary	City	Girls	562	29	5	1912	7,515	0.07	2,911	Government
14	Secondary	City	Girls	420	24	7	1999	1,800	0.23	1,720	Individuals Donation
15	Primary	City	Boys	600	26	5	2006	703	0.85	2,101	Donor Countries
16	Secondary	Town	Boys	268	20	5	2006	3,500	0.08	1,300	Government
17	Primary	City	Girls	293	18	5	1963	1,536	0.19	1,560	Government
18	Primary	City	Girls	114	7	2	1967	200	0.57	100	Individuals Donation
19	Primary	City	Girls	250	11	4	2001	320	0.78	675	Government
20	Primary	City	Boys	600	25	5	2002	4,655	0.13	2,260	Government
21	Primary	City	Boys	540	19	5	1908	1,230	0.44	2,135	Government
22	Primary	City	Boys	323	18	6	1944	2,500	0.13	1,500	Government
23	Secondary	City	Boys	462	27	5	1944	600	0.77	2,800	Government
24	Secondary	City	Boys	471	26	7	1908	785	0.60	1,800	Government
25	Primary	City	Both	357	15	5	2009	1,822	0.20	970	Donor Countries
26	Primary	City	Girls	231	13	4	2005	1,004	0.23	885	Government
27	Primary	City	Both	370	23	5	2002	320	1.16	350	Individuals Donation
28	Primary	City	Boys	365	20	2	2007	860	0.42	1,400	Donor Countries
29	Primary	City	Girls	470	22	5	2006	1,912	0.25	400	Government
30	Secondary	Village	Girls	390	23	5	2000	3,000	0.13	1,670	Government

31	Secondary	City	Girls	465	30	5	1978	2,000	0.23	800	Government
32	Primary	Village	Girls	242	16	3	1999	1,102	0.22	2,200	Donor Countries
33	Secondary	Town	Boys	280	20	5	2007	870	0.32	1,800	Donor Countries
34	Primary	City	Girls	400	18	4	1995	220	1.82	100	Government
35	Secondary	City	Girls	221	15	5	2020	1,900	0.12	560	Donor Countries
36	Primary	Village	Boys	175	8	9	2007	495	0.35	627	Government /Donor Countries
37	Primary	Village	Boys	299	18	4	2012	460	0.65	400	Donor Countries
38	Secondary	Village	Girls	559	28	7	2009	2,095	0.27	1,840	Individuals Donation
39	Primary	Village	Girls	375	15	4	1954	250	1.50	1,000	Government
40	Primary	City	Boys	259	12	5	2020	580	0.45	476	Donor Countries
41	Primary	City	Boys	627	28	7	1956	630	1.00	520	Government /Individuals Donation
42	Primary	City	Girls	50	5	3	1952	500	0.10	250	Government
43	Primary	Town	Boys	500	22	6	2008	2,160	0.23	2,443	Individuals Donation
44	Primary	Village	Both	203	10	3	2009	1,290	0.16	1,550	Government
45	Primary	City	Girls	116	9	3	1932	368	0.32	533	Government
46	Secondary	City	Girls	570	27	4	1977	1,000	0.57	1,245	Government
47	Primary	City	Girls	730	32	6	2006	2,355	0.31	1,700	Individuals Donation
48	Secondary	City	Girls	354	22	5	1911	1,970	0.18	700	Government
49	Primary	City	Girls	208	15	3	1920	677	0.31	690	Government
50	Primary	City	Girls	227	16	4	1957	1,229	0.18	489	Government
51	Secondary	City	Boys	500	21	5	1959	500	1.00	600	Government
52	Primary	Town	Boys	240	18	5	1980	800	0.30	1,000	Government
53	Primary	Village	Both	22	5	3	1970	120	0.18	0	Government
54	Primary	Village	Both	31	8	3	2008	250	0.12	400	Donor Countries

Table 5.2. The respondents' results for the energy-related items.

Environmental Aspect: Energy-Related Items								
No.	**Establishment year**	**Energy Consumption (kWh/m²)**	**Solar Panel**	**Solar panel Capacity (kW)**	**Insulation in Walls & Ceiling**	**Shading in South Elevation**	**Shading in East Elevation**	**Shading in West Elevation**
1	2015	6.08	No	---	No	No	No	No
2	1976	5.11	Yes	5	Yes	No	No	No
3	1988	7.47	Yes	16	Yes	No	No	No
4	2012	14.66	No	---	No	No	No	No
5	2008	6.64	No	---	No	No	No	No
6	2002	4.91	No	---	No	No	No	No

7	2004	5.89	No	---	No	No	No	No
8	2016	4.30	Yes	20	Yes	No	Yes	No
9	1950	16.72	No	---	No	No	No	No
10	2006	8.13	No	---	Yes	No	Yes	No
11	2000	2.35	No	---	No	No	No	No
12	2019	10.48	Yes	8	No	Yes	Yes	No
13	1912	2.48	No	---	No	No	No	No
14	1999	7.72	No	---	Yes	No	No	No
15	2006	11.53	No	---	No	No	Yes	Yes
16	2006	3.49	Yes	50	No	Yes	Yes	Yes
17	1963	3.85	No	---	Yes	No	No	No
18	1967	16.02	No	---	No	No	No	No
19	2001	22.78	No	---	No	No	No	No
20	2002	1.86	Yes	10	Yes	No	No	No
21	1908	12.05	No	---	No	No	No	No
22	1944	2.30	No	---	No	No	No	No
23	1944	10.92	No	---	Yes	No	Yes	Yes
24	1908	18.56	No	---	No	Yes	Yes	Yes
25	2009	6.18	Yes	10	No	No	No	No
26	2005	6.07	No	---	No	Yes	No	No
27	2002	50.71	No	---	Yes	No	No	No
28	2007	10.35	No	---	No	No	No	No
29	2006	7.60	No	---	No	No	No	No
30	2000	1.99	No	---	No	No	No	No
31	1978	3.95	No	---	No	No	No	No
32	1999	2.28	No	---	No	No	No	No
33	2007	3.57	No	---	No	Yes	Yes	Yes
34	1995	33.65	Yes	10	No	No	No	No
35	2020	4.33	No	---	Yes	Yes	Yes	Yes
36	2007	10.95	No	---	No	No	No	No
37	2012	13.51	No	---	No	No	No	No
38	2009	6.09	No	---	No	No	No	No
39	1954	38.32	No	---	No	No	No	No
40	2020	14.68	No	---	Yes	No	Yes	No
41	1956	21.95	No	---	No	No	No	No
42	1952	7.36	No	---	No	Yes	No	No
43	2008	6.30	Yes	5	No	No	No	No
44	2009	9.49	Yes	8	No	Yes	No	No
45	1932	16.77	No	---	No	Yes	Yes	Yes
46	1977	11.87	No	---	No	No	No	No
47	2006	9.39	No	---	No	No	No	No
48	1911	6.00	No	---	No	Yes	No	No
49	1920	8.24	No	---	No	No	No	No

50	1957	6.24	No	---	No	No	No	No
51	1959	27.09	No	---	No	No	No	No
52	1980	12.09	No	---	No	No	No	No
53	1970	18.53	No	---	No	No	No	No
54	2008	7.77	No	---	No	No	No	No

Table 5.3. The respondents' results for the water and sanitation item.

Environmental Aspect: Water and Sanitation Items				
No.	**Water Consumption (l/student.yr)**	**Rainwater Tank**	**Rainwater Tank size (m^3)**	**Sanitation**
1	1480	No	---	Septic tank
2	1406	No	---	Public sewers
3	882	No	---	Public sewers
4	1016	No	---	Public sewers
5	4657	No	---	Septic tank
6	3085	No	---	Public sewers
7	1130	No	---	Public sewers
8	1385	Yes	24	Septic tank
9	877	No	---	Public sewers
10	4924	No	---	Septic tank
11	2241	No	---	Septic tank
12	795	No	---	Public sewers
13	1441	No	---	Public sewers
14	741	No	---	Public sewers
15	365	No	---	Public sewers
16	3976	Yes	150	Public sewers
17	1592	No	---	Public sewers
18	3065	No	---	Public sewers
19	1128	No	---	Public sewers
20	795	No	---	Public sewers
21	3924	No	---	Public sewers
22	807	No	---	Public sewers
23	565	No	---	Public sewers
24	1738	No	---	Public sewers
25	833	Yes	32	Public sewers
26	7500	No	---	Public sewers
27	455	No	---	Public sewers
28	506	Yes	80	Public sewers
29	513	No	---	Public sewers
30	589	No	---	Public sewers
31	3936	No	---	Public sewers

32	2529	No	---	Public sewers
33	967	No	---	Public sewers
34	431	Yes	15	Public sewers
35	880	No	---	Public sewers
36	4234	No	---	Septic tank
37	991	No	---	Public sewers
38	387	No	---	Septic tank
39	3726	No	---	Septic tank
40	1188	No	---	Public sewers
41	1236	No	---	Public sewers
42	845	No	---	Public sewers
43	602	No	---	Septic tank
44	1639	Yes	50	Septic tank
45	1070	No	---	Public sewers
46	529	No	---	Public sewers
47	533	No	---	Septic tank
48	472	No	---	Public sewers
49	544	No	---	Public sewers
50	518	No	---	Public sewers
51	413	No	---	Public sewers
52	1996	No	---	Septic tank
53	9667	Yes	80	Septic tank
54	4405	Yes	40	Septic tank

Table 5.4. The respondents' results for the site development aspect.

Environmental Aspect: Site Development Items									
No.	**Green Area (%)**	**Shading Area (%)**	**Heat Island Effect**	**Waste Separation**	**No.**	**Green Area (%)**	**Shading Area (%)**	**Heat Island Effect**	**Waste Separation**
1	10	11	Low SRI Surface	No	**28**	3	8	Asphalt	No
2	14	10	Asphalt	No	**29**	15	26	Asphalt	Yes
3	0	33	Asphalt	No	**30**	1	3	Asphalt	No
4	25	20	Asphalt	No	**31**	14	25	Asphalt	No
5	6	19	Asphalt	No	**32**	13	5	Low SRI Surface	No
6	0	2	Asphalt	No	**33**	4	5	Asphalt	No
7	1	1	Asphalt	No	**34**	3	0	Asphalt	No
8	25	6	Low SRI Surface	No	**35**	24	1	Asphalt	No
9	0	0	Asphalt	No	**36**	2	4	Asphalt	No
10	10	13	Asphalt	No	**37**	0	2	Low SRI Surface	No
11	13	38	Asphalt	No	**38**	12	0	Asphalt	No
12	0	4	Low SRI Surface	No	**39**	2	1	Asphalt	Yes
13	4	12	Asphalt	No	**40**	15	4	Asphalt	No

14	5	8	Asphalt	No	**41**	0	44	Asphalt	No
15	25	4	Asphalt	No	**42**	0	52	Low SRI Surface	No
16	1	1	Asphalt	No	**43**	2	10	Asphalt	No
17	1	6	Asphalt	No	**44**	39	1	Asphalt	No
18	0	50	Asphalt	No	**45**	6	4	Low SRI Surface	No
19	1	19	Asphalt	No	**46**	23	16	Asphalt	No
20	10	19	Asphalt	No	**47**	9	10	Asphalt	No
21	15	8	Asphalt	No	**48**	13	4	Asphalt	No
22	3	7	Asphalt	No	**49**	0	9	Low SRI Surface	No
23	3	2	Asphalt	No	**50**	1	16	Low SRI Surface	No
24	13	11	Low SRI Surface	No	**51**	16	30	Asphalt	No
25	15	41	Asphalt	No	**52**	1	3	Asphalt	No
26	1	19	Asphalt	No	**53**	33	0	Low SRI Surface	No
27	15	29	Asphalt	No	**54**	10	13	Asphalt	No

Table 5.5. The respondents' results for the economic aspect.

Economic Aspect									
No.	**Mainten-ance Cost ($/yr)**	**New Teachers** (#)	**New Staff** (#)	**Social Activities**	**No.**	**Mainten-ance Cost ($/yr)**	**New Teachers** (#)	**New Staff** (#)	**Social Activities**
1	280	3	0	No	**27**	1,390	2	5	No
2	1,110	2	1	No	**29**	830	1	0	No
3	695	0	0	No	**30**	1,667	0	0	Yes (return $0)
4	280	2	0	Yes (return $140)	**31**	1,945	2	0	No
5	830	0	1	No	**32**	500	1	0	No
6	280	0	0	No	**33**	330	1	0	No
7	1,390	2	1	Yes (return $0)	**34**	560	0	6	No
8	556	5	1	Yes (return $140)	**35**	1,667	0	0	No
9	1,390	0	0	No	**36**	560	1	0	No
10	1,110	1	0	No	**37**	1,110	0	0	No
11	667	1	1	No	**38**	350	0	0	Yes (return $140)
12	1,667	1	0	No	**39**	420	0	0	No
13	305	1	0	Yes (return $0)	**40**	830	0	0	No
14	280	2	1	No	**41**	350	2	1	No
15	1,390	6	0	No	**42**	560	0	0	No
16	2,220	0	5	No	**43**	1,835	4	0	Yes (return

									$140)
17	1,390	0	0	Yes (return $0)	**44**	560	10	3	No
18	380	0	0	No	**45**	830	1	0	No
19	1,370	0	0	No	**46**	560	1	0	No
20	1,800	2	0	No	**47**	330	1	0	Yes (return $0)
21	280	1	0	Yes (return $140)	**48**	1,750	2	0	Yes (return $0)
22	1,390	0	6	No	**49**	950	2	0	No
23	280	0	5	Yes (return $0)	**50**	860	1	0	No
24	600	4	0	No	**51**	560	2	0	No
25	1,390	0	0	No	**52**	1,110	4	1	No
26	1,390	0	4	No	**53**	1,390	0	1	No
27	500	1	0	Yes (return $110)	**54**	830	0	0	No

Table 5.6. The respondents' results for the social equity in social aspect.

Social Aspect: Social Equity											
No.	**Low-Income Student (%)**	**Disabled Student (%)**	**Teacher Partici-pation (%)**	**Parent Partici-pation (%)**	**Student Partici-pation (%)**	**No.**	**Low-Income Student (%)**	**Disabled Student (%)**	**Teacher Partici-pation (%)**	**Parent Partici-pation (%)**	**Student Partici-pation (%)**
1	4	4	20	10	1	**27**	8	4	15	7	7
2	3	1	20	5	4	**29**	10	3	10	6	2.5
3	10	0	5	5	0	**30**	26	1	25	10	2
4	3	2	10	2	2	**31**	6	3	10	5	3
5	5	0	25	9	5	**32**	5	0	25	12	5
6	4	3	30	6.5	8	**33**	6	2	35	4	5
7	7	1	25	10	5	**34**	8	0	25	3	1
8	7	0	30	12	5	**35**	7	0	30	8	8
9	10	1	32	10	0	**36**	3	0	20	12	0
10	1	0	30	12	1	**37**	3	0	20	3	0
11	6	1	32	12	1	**38**	8	1	8	12	2
12	18	2	25	10	3	**39**	8	1	20	7	6
13	9	1	30	12	5	**40**	2	1	30	8	3
14	9	4	10	3	9	**41**	14	0	25	10	1
15	9	3	30	3	4	**42**	32	8	30	12	2
16	4	0	10	5	5	**43**	2	2	20	7	5
17	12	7	20	5	2	**44**	2	7	30	7	7
18	26	0	25	3	1	**45**	6	2	5	5	3
19	4	0	25	12	2	**46**	1	0	30	12	3
20	4	2	15	8.5	1	**47**	10	0	10	5	2
21	6	1	10	12	2	**48**	5	0	10	6	5

22	9	0	20	10	5	**49**	10	2	25	7.5	7.5
23	6	0	25	12	3	**50**	7	0	25	12	5
24	2	1	25	3	2	**51**	1	0	25	12	2
25	2	0	20	8	4	**52**	2	4	20	12	1
26	4	0	10	12	4	**53**	14	9	20	10	0
27	16	1	30	7	5	**54**	6	0	25	12	1

Table 5.7. The respondents' results for the Teaching quality and accessibility in social aspect.

Social Aspect: Teaching Quality & Accessibility							
No.	**Attendance Rates (%)**	**Sick Absence Rate (%)**	**Success Rate (%)**	**Dropout rate (%)**	**Parking Area (%)**	**Access to Public Transportation (m)**	**Accessibility**
1	99	1	98	2	42	450	Not easy
2	93	2	100	2	18	1,500	Easy
3	99	1	100	0	0	400	Easy
4	100	5	100	0	0	400	Easy
5	85	1	78	2	0	2000	Easy
6	98	1.5	98	1	0	400	Easy
7	80	2	95	0	0	1,000	Easy
8	95	2	98	2	48	1,200	Easy
9	100	5	97	0	0	400	Easy
10	90	5	100	0	0	400	Easy
11	95	2	98	6	0	400	Easy
12	90	7	75	0	0	500	Easy
13	98	2	99	0	39	400	Easy
14	90	8	96	1	0	400	Easy
15	96	0	100	0	43	400	Easy
16	90	5	99	8	13	400	Easy
17	90	2	85	1	0	400	Easy
18	90	5	100	0	0	400	Easy
19	100	0	100	0	0	500	Easy
20	90	1	75	3	0	600	Easy
21	97	1	100	0	0	400	Easy
22	95	5	98	0	0	400	Easy
23	75	2	95	7	8	400	Easy
24	97	3	97	1	0	1,000	Easy
25	80	2	100	0	0	400	Easy
26	100	2	100	0	0	1,000	Easy
27	95	5	98	1	0	400	Easy
28	85	2	97	2	30	400	Easy
29	60	4	80	0	0	400	Not easy
30	95	3	95	2	7	400	Easy
31	99	1	80	6	0	400	Easy

32	95	4	100	0	0	400	Easy
33	80	2	75	0	0	500	Easy
34	98	1	90	1	0	400	Easy
35	88	2	91	3	0	400	Easy
36	95	5	100	0	0	400	Not easy
37	97	5	99	0	0	400	Easy
38	95	5	75	1	0	400	Easy
39	95	1	100	0	0	400	Easy
40	86	9	100	0	0	400	Easy
41	95	3	90	0	0	400	Easy
42	96	4	100	0	0	400	Easy
43	98	8	100	0	0	500	Easy
44	99	0	100	0	0	400	Easy
45	98	1	100	0	0	400	Easy
46	95	2	90	0	0	400	Easy
47	80	3	80	5	0	400	Easy
48	90	1.5	95	3	0	400	Easy
49	90	1	95	0	0	400	Easy
50	95	2	93	2	0	400	Not easy
51	96	2	75	1	0	400	Easy
52	97	3	100	0	58	400	Easy
53	100	2	100	0	0	700	Not easy
54	98	5	100	3	0	3000	Not easy