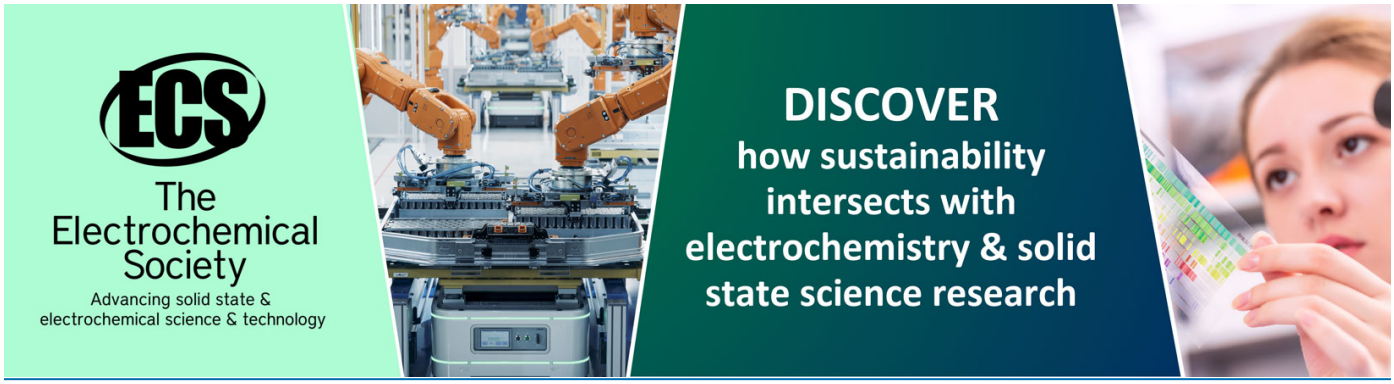
Sustainability in the Design of Passenger Terminals for Airports



IOP Conf. Series: Materials Science and Engineering **745** (2020) 012141 doi:10.1088/1757-899X/745/1/012141

Sustainability in the Design of Passenger Terminals for Airports

Aseel Saleem Hussain[1], Anwar Subhi Ramdan[1]
[1]Master Student, Department of Architectural Engineering, University of Technology, Baghdad, Iraq, Email: eng.aseelsaleem@yahoo.com

Abstract. Contemporary trends in the design of passenger terminals have been linked to the concept of sustainability in terms of its endeavor to upgrade in order to suit the requirements of the current era, namely the integration of environmental, social and economic aspects that apply the principles of sustainability in the planning, design and operation of its various spaces, this is highlighted by the previous studies, although the introduction of them in most cases is general and implicit, and selectively in adopting and treating some aspects and not knowing how to apply in local experiences so far, the research problem was determined by the incomprehensiveness of knowledge on the dimensions of sustainability (environmental, social and economic) in the design or various treatments of airport terminals and ways of applying them in local reality, the main objective is to introduce this knowledge in a more comprehensive and clear manner, and to provide the possibility to achieve it locally, achieving this goal has necessitated the adoption of a descriptive-analytical approach to the studies and practical projects to build a comprehensive theoretical framework that defines the various dimensions of sustainable passenger terminals. To be applied at selected local case study in the form of an evaluation study of the reality situation, leading to the identification of conclusions and recommendations.

1. Introduction

Passenger terminals are one of the basic facilities and services at the airports, and one of the most important parts of the infrastructure required to operate the airports regularly, also they play a vital role in the local and global economies and provide clear social benefits. And as a result of the increasing demand for air traffic for passengers and goods, a need has been emerged to build new passenger terminals, or expand and operate existing terminals, thereby reducing the environmental costs and impacts of their operations by taking into account sustainable development issues and realizing their different practices to create a balanced approach to maximize their capabilities and potential environmentally, socially and economically.

Sustainable passenger terminals can be defined as those in which the principles of sustainability are applied when designing new ones or operating and maintaining existing terminals with their various internal and external spaces, with basic considerations of design patterns, as well as considerations of movement and flexibility, within an approach that integrates environmental, social and economic aspects. Environmental aspects deal with limiting pollution and reducing its impact based on global environmental assessment systems, while social aspects achieve the highest levels of passenger satisfaction in addition to the sustainability of awareness and education providing a high economic return depending on providing investment spaces within them with multiple privileges that support the national economy, companies and individuals.

2. Environmental sustainability in passenger terminals

The research adopted several previous studies and researches to determine the basic levels of dealing to achieve the environmental sustainability of passenger terminals. Previous knowledge has been classified and arranged based on the LEED Global Classification system "due to its global spread and popularity, as well as the environment of the emergence of the LEED system in the United States which occupies the continent of North America that has a diverse and different range of climatic environments. This supports the reason why it was chosen as an ideal study model" [1], as it has been adopted in many airports. Arab countries are going to adopt it in accordance with their climate environment, within its supported categories in the design of airports, which include a new design, implementation, operation and maintenance, interior design and construction. These levels are represented by:

2.1 Location and Transportation

This level is to deal with the nature of the planning and design of passenger terminal sites and the adoption of means of transport, whether the design and implementation of a new station or operation and maintenance of an existing station and according to each of the following:

- Site development: In terms of laying out the station near car parks, car rental areas and services centre, as well as centralizing the location between runways to reduce runway and taxiway distances and to shorten transport time [2].
- Sensitive land protection: In terms of selecting suitable sites within the limits of biological development, reducing the environmental impact of the site and environmentally sensitive land in terms of avoiding major agricultural lands, flood plains, habitat areas, water areas, and wetlands [3].
- Alternative Transportation: Adopting alternative transportation (walking, cycling, public transport, teleworking, informal transportation options, green vehicles, etc.) and promoting access to transit quality (multiple transports) as bus stops, tram stations and heavy and light railway stations [4].

2.2 Sustainable Sites

This level represented by the criteria to be taken in selecting a sustainable site and reducing the environmental impact of a new plant, and the possibilities can be adopted in the development and rehabilitation of the site of an existing station, according to the following:

- Pre-design site assessment: represented by a topographic survey, hydrology detection, climate analysis, vegetation survey, soil survey, human use detection and human health affect analysis.
- Pollution reduction for construction activities: represented by soil erosion and waterway sediment control, and airborne dust reduction [3].
- Site development- habitat's protection: represented by a restoration of affected areas and conservation of spare green areas.
- Heat island reduction: in terms of reducing the over construction and treatment of horizontal surfaces by covering parking lots with plant ceilings or solar power generation systems, etc.
- Treatment of other surfaces through shading with trees, plants, and power generation structures, use of various solar breakers, light shelves, and screen walls [5] [6] .

2.3 Water usage efficiency

This level represented by the importance of preserving the water and identifying sustainable practices to reduce its consumption and rationalize its use according to the following:

- Indoor water use reduction: in terms of setting sensitive installations (automatic sensing), continuous maintenance and identification of leaks, the use of efficient equipment and the adoption of a water-saving irrigation system for indoor gardens.
- Outdoor water use reduction: in terms of the use of local drought-resistant plants, the adoption of a water-saving irrigation system, etc.
- Water Metering: Measuring the level of water consumption by adopting meters, using recycled water for cooling plant towers, storing and collecting rainwater for non-drinking uses, etc. [7] [4]

2.4 Energy and atmosphere conservation

This level represented by the use of processors in the terminal that reduce energy consumption, which can be adopted when designing a new terminal or operation and maintenance of an existing terminal as well as interior design, in addition to the operational efficiency of various devices and structures and the importance of efficient environmental management and the adoption of renewable energies according to the following:

- Minimum energy performance: through improving energy performance by adopting thermal insulation of the terminal, distributing and reflecting light, as well as using energy-saving structures in terms of the use of LED lamps, adopting works sensors through CO2 monitoring, the use of effective and efficient devices and installations, the use of lighting control system and determination of the correct sizes of equipment.
- Advanced energy metering: in terms of installing meters to support management and identifying additional energy-saving opportunities, as well as energy use plan and future needs [5] [6] .
- Efficient management: the adoption of an orderly sequence in the operations of the building, the adoption of the schedules of the building works, the adoption of the operating schedule of equipment, whether air conditioning equipment or lighting levels, taking into account the minimum requirements for cooling, adjusting changes to the schedules, whether for different seasons or days of the week or times of day, the use of mechanical and electrical equipment description systems in the building, the development of a preventive maintenance plan for building equipment, and the promotion of air cooling management using natural or industrial cooling that reduce ozone depletion, as well as the management of basic energy systems [4].
- Renewable energy production, whether using solar energy using photovoltaic, wind energy, hydropower, geothermal energy, biomass energy, etc. [8].

2.5 Materials and resources

This level is the adoption of strategies to improve and recycling the materials, and the adoption of green procurement practices, as follows:

- Building product disclosure and optimization: represented by the flexibility of environmental product data using environmentally and socially preferred materials that meet a global standard, determining the sources of raw materials whether biomaterials, wood products, recycled content, local sources, low volatile organic emissions, sustainable agriculture and taking into account the components of the materials and determining their risks by adopting health and safety programs [9] [7].
- Construction and demolition waste management planning.
- Establishment of sites for storage and collection of recyclable materials.
- Green purchasing: The environmentally preferable purchase policy (EPP) for products during the regular operations of the building, purchasing devices according to energy star / energy efficiency certificates, using green cleaning products, reviewing chemical purchases and determining whether there are opportunities to reduce toxicity or purchase other materials, developing and implementing specifications for fuel and equipment to reduce emissions, etc. [10] [2].

2.6 Indoor Environmental Quality

This level represented on the adoption of air quality, lighting, thermal comfort and sound performance considerations, and as follows:

- Indoor air quality: in terms of the adoption of air treatment units in the building, the adoption of air handling units for the outflow of air, the design of good spaces for ventilation, the thermal division of the areas into multiple cooling, and prevent smoking inside the building except for areas designated for smoking, as well as the promotion of indoor air quality strategies by adopting inlet systems for cleaning dirt and particulate matter, placing filters in ventilation systems, adopting a system to generate high CO2 alarm, using automatic signalling devices for minimum opening, as well as reducing volatile organic compounds (VOCs) affecting human breathing, etc. [2] [9] .
- Interior lighting: represented by the adoption of natural lighting through the adoption of multiple lines glass vision in different directions, as well as the quality of the external look and visual

clarity through a broad view of the aircraft and take-off to reduce tension and positive feeling, as well as the artificial lighting through control lighting to meet user needs and preferences (on / off , mid-level), and providing high quality lighting sources with a lifespan of at least 24,000 hour[8] .

- Thermal comfort management: represented by the adoption of systems for continuous tracking and improvement of occupied places (temperature, radiation, humidity and airspeed), continuous monitoring, periodic testing and maintenance [11].
- Acoustic performance: through the processing of internal noise with effective sound design, the treatment of external noise using materials, finishes, and the adoption of angled exterior walls to reduce noise, etc.
- Green cleaning: represented by the management policy in terms of standard operating procedures for cleaning, maintenance, with management for them and continuous scrutiny, protection of occupants of the building at risk during cleaning, selection of suitable materials and disinfectants for use, safe handling and storage of detergent chemicals, promote the conservation of energy, water and chemicals in cleaning, strategies to improve and promote hand hygiene, as well as products and materials in terms of reducing the environmental impacts of cleaning products, convertible paper and garbage bags, and integrated pest management in terms of providing integrated pest management teams, continuous inspections and surveillance, non-chemical preventive measures for pests [10] .

2.7 Innovation

It is the adoption of innovative strategies in the design and operation of the terminal as well as environmental assessment certificates recognized as follows:

- Design of a multi-sensory station visually in terms of masses, materials and colours, acoustically by sounds, smell by odors and touching by masses and materials.
- Simulation of nature: in terms of simulation within the internal environment through natural indoor gardens, green walls, embedding water in terms of waterfalls, indoor streams, pools, open spaces and representation of the sun, etc., and simulate nature within the external environment through the site and the surrounding environment, area features, surrounding buildings, etc. [5]
- Physical expressive level: in terms of the level of expression of origin, and the level of expression of function.
- In addition to adopting innovative treatments that contribute to obtaining recognized environmental assessment certificates (such as LEED), etc. [7]

2.8 Regional environmental priority

This represented by the adoption of environmental strategies and remedies to suit the regional environment of the terminal in terms of the following:

- The space division according to the level of works, activity and thermal zones for each facade and according to the regional environment.
- The adoption of appropriate regional environmental remedies, etc.[6]

In light of the above, the main levels associated with the environmental sustainability of passenger terminals can be summarized according to LEED system categories in ' Table 1 '.

Table 1. The environmental sustainability levels of passenger terminals within the three LEED categories (researchers)

Sub-elements	Possible values	Categories supported		
		BUILDING DESIGN AND CONSTRUCTION	Operation and maintenance	Interior Design
Site and transport	Site development	•		
	Protection of sensitive ground	•		
	Alternative transport	•	•	
Site sustainability	Pre-design site evaluation	•		
	Pollution reduction for construction activities	•		
	Site development - habitat protection	•	•	
	Thermal island reduction	•	•	
Water efficiency	Reduce indoor water use	•	•	•
	Measuring the level of water consumption by using meters	•	•	•
	Reduce water use in outdoor areas	•	•	
	Use recycled water for cooling plant towers	•	•	
	Storage and collection of rainwater for non-drinking uses	•	•	
Saving energy and atmosphere	Reducing energy consumption	•	•	•
	Measuring power consumption	•	•	•
	Efficient management	•	•	•
	The adoption of renewable energy	•	•	•
Materials and recourses	Detection and improvement of construction products	•		•
	Planning of waste management for construction and demolition	•	•	•
	Construction of storage sites and collection of recyclable materials	•	•	•
	Green purchase			
Quality of the internal environment	Indoor air quality	•	•	•
	Interior lighting	•	•	•
	Thermal comfort management	•	•	•
	Acoustic performance	•		•
	Green cleaning		•	
Innovation	Multi-sensory plant design	•	•	•
	Nature simulation: Within the internal environment	•	•	•
	Nature simulation: Within the external environment	•		
	Physical expressive level	•		
	Adoption of innovative processors that contribute to recognized environmental assessment certificates (eg. LEED)	•	•	•
	Others			
Regional Environmental priority	Space division according to the level of works, activity and thermal zones for each facade and according to the regional environment	•		
	Adoption of appropriate regional environmental remedies			
	Others	•		

3. The social sustainability of passenger terminals

The passenger terminal is the first and last point of the passenger's arrival and departure for a country, and therefore, must be designed to reflect the progress and sobriety of national and regional aviation, as well as the progress and development of countries within a diversity and cultural richness, taking into account making passengers do not feel confused and reduce tension by meeting social requirements.[12]

Previous studies have pointed to many aspects related to the social dimension of sustainable passenger terminals, as well as the various treatments adopted by contemporary projects, which this research categorized within two main categories:

3.1 Achieving passenger satisfaction

Passenger terminals seek to achieve the social dimension of sustainability by achieving the general satisfaction of passengers for the design treatments adopted in the terminal providing a distinctive experience in line with the requirements of the era, as well as achieving the comfort of the level and speed of service delivery, and can be summarized as:

- Respecting the local context: It is important to design a local structure that reflects the culture and environment of the country to enhance its attractiveness and spatial sense, in terms of building a station with a distinctive local context and adapted to the surrounding environment, according to the climate, vegetation, and kind of the surrounding or distinctive buildings in the region. The local culture and community values, or the existence of local civil aviation heritage, can make it an integrated structure with the environment. The study also emphasized the enhancement of the quality and sustainability of the gateway experience by invoking the local geographical and cultural environment. [4]
- Providing attraction: It is important to provide attraction by opening to the outside, the view towards the aircraft, the height of spaces, the diversity of functions and spaces and the density of residents in the place [11]. Based on this, the scale is manipulated, diversity and balance are promoted and rhythm and repetition are adopted.
- Promotion of art: in terms of the adoption of the art of murals and sculptures reflecting local or global originality in general and even those associated with aviation in particular [13], in the various parts of the terminal (horizontal and vertical surfaces), as well as holding art exhibitions (permanent and temporary).
- Enhancing the experience of travellers: Many travel terminals seek to break the traditional stereotypes by conducting events that enhance the experience of travellers such as entertainment and cultural performances, in addition to promotions and others.
- Interactive Social Communication: Modern passenger terminals today adopt the latest interactive technologies in their various functions and detailed treatments.
- Achieving comfort in the speed of services: It highlights the importance of achieving the quality of services, whether by directing passengers or maintaining the time limit for them.[11]

3.2 Awareness and education

The importance of activating training and qualification programs for employees is highlighted to develop the capabilities of engineers working in the civil aviation sector in designing sustainable airports and rooting the culture of sustainable design [8], enhancing the context of the interactions between many shareholders within the airport system of government staff, employees, shopkeepers and merchants, owners of airport shares, airlines and travellers, and make sure to spread awareness and education by various means and establishing the foundations and workshops, promoting public health, welfare and teamwork among employees [13].

The social dimension is an important factor in the design of many passenger terminals at the world's airports. Singapore Changi Airport Terminal, for example, has taken care of social design considerations by providing attraction, combining multiple functions and embedding natural wealth, and enhancing the travellers' experience through holding various celebrations and performances, and to achieve social communication between travellers through the transparent walls and various interactive services. The terminal has provided amenities for travellers and to reduce time through smart self-use systems, and promoting art and industrial production to reduce the travellers' waiting time and tension , ' Figure 1' [14].

Figure 1. Achieving social sustainability at Changi Airport Terminal in Singapore (https://www.archdaily.com) (Changi Airport Report, 2016, P44)

Seoul Incheon Airport Terminal designed to meet the social requirements of providing an attractive water element within the terminal, promoting ancient art to document the country's history, improving the experience of travellers with various museums and exhibitions, as well as free transit tours, and social networking by including robots and interactive screens. The station reflected the local context and culture and added the spatial sense of the country, providing convenience and time for travellers using different smart self-use systems, ' Figure 2' [15].

Figure 2. Seoul Incheon Airport Terminal (Hye-Jin and Ye-Kyeong,2016, P207) (https://m.ra2ej.com)

Baku Airport Terminal in Azerbaijan has been characterized by innovation in the design of its interior spaces in a natural experimental way that reflects the hospitality and welcoming of the country and gives opportunities to meet and interact between travellers, while achieving the social dimension by providing attraction and finding the balance between the blocks and decorations, planning of shadow and light, while integrating the huge scale and human scale in its internal spaces to enhance the sense of intimacy and analogy of the terminal by a village, as well as the use of natural materials such as wood, stone and textiles , ' Figure 3' [16]

Figure 3. Baku Airport Terminal (https://www.dezeen.com)

The design of Doha Hamad Airport Terminal reflects the cultural heritage and natural environment of the country and highlights the local image as a gateway to the country in the world. The art in the station has been promoted and the public culture of the country has been enhanced in terms of supporting the work of local artists, documenting huge murals, promoting sculptures and objects, holding temporary and permanent exhibitions, as well as intelligent and interactive electronic systems and providing quick services for the convenience of travellers, ' Figure 4' [17] .

Figure 4. Doha Hamad Airport Terminal (https://www.hok.com)

Tokyo Airport Terminal, Haneda, is characterized by an innovative multi-sensory design that gives the country's first impression, providing services for the convenience of travellers using various mechanical means to reduce walking distances, and multilingualism as well as service for people with disabilities, the elderly and infants, in addition to the inclusion of awareness and education among employees and achieving interaction between them, ' Figure 5' .[18]

Figure 5. Tokyo Airport Terminal, Haneda (http://www.jma.co.jp/projects/new-haneda-airport)

4. Economic sustainability in passengers' terminals

The passenger's terminal is economically important. Its economic attractiveness lies in the fact that it provides access, speed and agility to the global export chain, connecting businesses to its customers and partners and providing services that meet the needs of millions of air passengers, tourists and visitors, thus, contributing to the development of the workplace, shopping, tourism, trade and the important businesses themselves[19] .

The previous studies have pointed to many aspects related to the economic dimension in airports in general and passenger terminals in particular, as well as the various treatments adopted by contemporary projects, which this research has categorized within two main categories:

4.1 Provide various investment areas

The range of non-aviation activities such as logistics services, sales kiosks, industries, research and development, hotels, entertainment, offices, exhibition centers, and other services in the interior and even surrounding areas of the terminal, such as parking and multiple-use areas, are economically benefited, because they provide multiple job opportunities, on one hand, and as financial resources, on the other.[19] [20]

For example, Amsterdam Schiphol Airport Terminal has achieved high economic revenues through attractions for its travellers including museums, libraries, fitness facilities, resting places and relaxation rooms[21], Dubai Airport Terminal has also achieved various economic considerations from long-term agreements, restaurants services, shopping, miscellaneous brands, station floor rental resources and commercials, as well as parking and transportation fees. [22]

4.2 Seeking other economic concessions

The operation and management of the various activities of the airport, in general, and the passenger terminal, in particular, contribute to the support of income and local production. The economic activity generated by employees of companies directly or indirectly associated with the airport whose income is spent in the national economy, for example an employee of an airline Company may spend his income on grocery stores, restaurants, childcare, dental services, home renovations and other materials that in turn generate work in a wide range of sectors of the general economy [19].

Many terminals seek to provide multiple economic concessions. For example, Singapore's Terminal, Changi, has benefited from increased flights at a high level to increase airline revenue [23]. Hong Kong Airport Terminal has expanded its air interface area to increase revenue from aircraft parking fees [24]. The Frankfurt Airport Terminal has benefited economically from the imposition of fees and taxes on airlines because of harmful environmental emissions and aircraft noise [25]. Dubai Airport Terminal has invested in concessions, ground management and fuel savings to enhance its economic aspects [22].

5- The practical study

In order to reach a clear vision about the reality of local airports in terms of the requirements of the sustainable passenger terminal by conducting an assessment study which is in line with the research objective, Baghdad International Airport has been chosen, specifically the passenger terminals therein, representing the model which includes: Samarra, Babylon and Nineveh terminals, which are similar in repeated design, consistent with the time and capacity of the search (due to the difficulty of application on all passenger terminals at Iraqi airports), and as a general model that can be adopted in the rest of

the passenger terminals at local airports as shown in ' Figure 6'. In general, the research assumes that local passenger stations built with local models achieve some environmental and economic aspects while lacking the social dimension of passenger satisfaction.

The British consultant (Monsal) has prepared initial designs of the airport, while two French companies (Fougerolle and Spie Patignolles) implemented the project. The design of the terminal depends on the pattern of the terminal building (Terminal Unit). Each building is fully integrated with its services and activities. The units have been assembled on the perimeter of a semi-circle served by two-story vehicles for departure and arrival. Each terminal has a capacity of 2.5 million passengers per year, a total of 7.5 million passengers per year. Moreover, the base form of the terminal is based on the equilateral triangular shape of 19 meters in length and it is repeated as a basis to create functional and structural formations. As shown in ' Figure 7' [26], Babylon building allocated to foreign airlines and Nineveh building to Iraqi Airways, while the maintenance and rehabilitation were continuing in Samarra building. The three passenger terminals were marked in different colors including (blue for Samarra, green for Babylon and yellow for Nineveh) [27]. The stations are similar in schemes, form, and connected by links containing services, management offices, and the two corridors of ground and airside. Each building includes six parking lots for different sizes aircrafts [28].

5.1 Type of measurement and data collection method

This section describes a basic aspect of the application, represented by the type of measurement presented for the application elements using two types of measurements. The first is the descriptive-analytical measurement of the selected terminal for each of the first and third application terms (environmental sustainability of passenger terminals, the economic sustainability of passenger terminals). The method of data collection included reliance on some studies, websites and reports from the owner, as well as a descriptive analysis of researchers according to pictures, charts, survey and personal interviews. The second type of measurement is based on the questionnaire related to the second application vocabularies (social sustainability of passenger terminals), which was filled by passengers and staff at the passenger terminals of Baghdad International Airport.

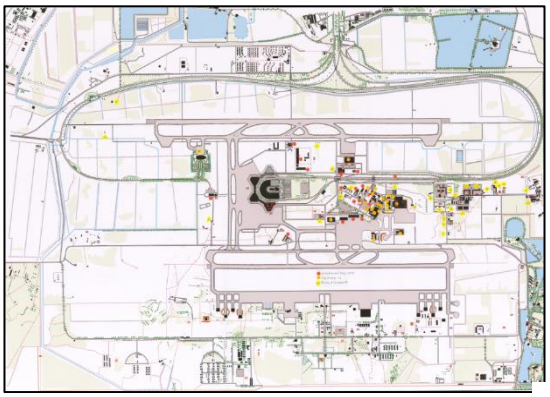


Figure 6. The layout of the general location of Baghdad International Airport (Technical Library, Baghdad Airport)

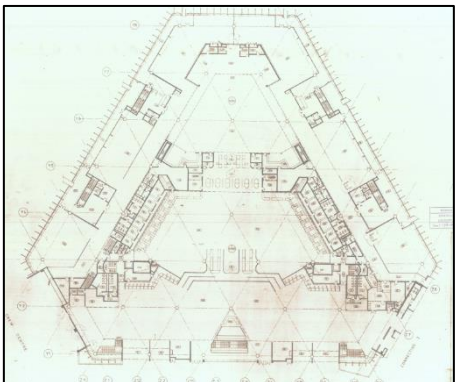


Figure 7. Babylon passenger station - first floor plan / departure hall (Technical Library, Baghdad Airport)

5.1.1 Environmental sustainability analysis and measurement

The application model for passenger terminals at Baghdad International Airport was analysed and described for environmental sustainability by adopting the category of operation and maintenance of existing terminals. Some environmental aspects achieved in terms of the following:

- Site and transport: the use of alternative transport achieved through public transport and informal transportation options, as shown in ' Figure 8'.
- Site sustainability: Achieved through the site development and the restoration of the affected areas, as well as the preservation of the green reserve areas, and the adoption of treatments to alleviate

thermal islands by shading trees and plants, and the use of solar breakers with three types of horizontal, vertical and complex to reduce direct sunlight, as shown in ' Figure 9'. In addition to the use of optical shelves in the openings and windows surrounding the terminal [29].

Figure 8. Alternative transport in the first model) Photographed researchers)

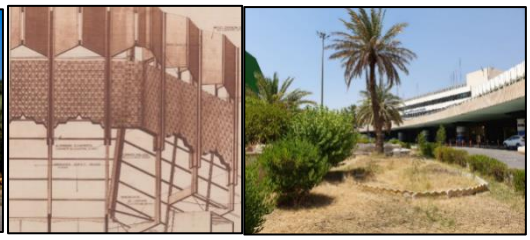


Figure 9. Mitigation of thermal islands (Technical Library)(Photographed researchers)

- Water Efficiency: Sensitive formulations (automatic sensing) were achieved to reduce water use in indoor spaces, continuous maintenance and identifying leaks, measuring water used with meters, reducing water use in outdoor areas by adopting water-saving irrigation system and using drought-resistant local plants, the use of rainwater storage and harvesting strategy for non-drinking uses, as shown in ' Figure 10' [30].
- Energy and atmosphere conservation: Improved energy performance by thermal insulation was achieved using double walls, double glazing and absorbing red sunlight, with insulation for ceilings, floors and foundations, as well as the distribution of light and reflecting it using finishes and colors [26], the use of energy-saving LED lamps, the adoption of meters in most systems to measure energy consumption and identify opportunities for additional energy saving, as well as efficient management of the terminals through building occupancy schedules, equipment operation schedules, description of mechanical and electrical equipment in the building, preventive maintenance plan for building equipment, use of HVAC systems as one of the basic systems for energy management [31].
- Materials and resources: Achieving green purchases by purchasing devices according to energy efficiency certificates and well-known international companies.
- Quality of the indoor environment: Adoption of air treatment units in the building as shown in ' Figure 11', achieving the presence of good spaces for ventilation, and achieving indoor air quality by preventing smoking inside the building except for areas designated for smoking as shown in ' Figure 12', as well as the use of entrance systems to clear dirt and stuck particles through grids as shown in 'Figure 13', and the presence of filters in ventilation systems. The clear visual vision is achieved using natural lighting through windows only, as well as the quality of the external view by looking at the aircraft to reduce tension and give positive feeling [27]. High quality synthetic lighting is used with a minimum age of 24000 hrs, with green cleaning policy achieved by setting standard operating procedures for cleaning, maintenance, management and continuous scrutiny, use of safe storage and handling sites for chemicals and detergents, as well as providing integrated pest management through providing control teams, ongoing inspections and monitoring [32].

Figure 10. Storage and collection of rain water (researchers)

Figure 11. Air treatment units and filters(researchers)

Figure 12. Smoking rooms inside the terminal(researchers)

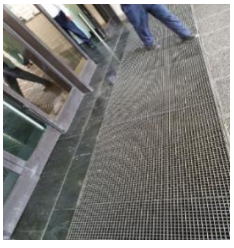


Figure 13. Entrances systems for cleaning(researchers)

- Innovation: No innovative strategies been used at Baghdad airport's passenger terminals or the adoption of a global environmental assessment system to evaluate the airport.

5.1.2 Analyzing and measuring social sustainability

This term describes an important aspect of the application of the analysis of social aspects, therefore the qualitative measurement was based on the extraction of sub-vocabularies in the term of social sustainability in passenger terminals (passenger satisfaction, awareness and education) directly adopted through the questionnaire distributed to passengers and employees in various passenger terminals of Baghdad airport. Two types of questionnaire forms were designed according to questions with specific answers on the tripartite Likert scale, which were filled by the individuals surveyed to include:

- Questionnaire forms belonging to passengers, aimed at determining the satisfaction of passengers in the application model and the values achieved, with the inclusion of forms for treatments and proposals to achieve their satisfaction in the unrealized values. The total number of passengers was 28 passengers, including 20 Iraqi, 3 Arab, and 5 foreign passengers.
- Questionnaire forms for 24 employees, aimed at determining the awareness and education of the staff.

A small percentage of the values pertaining to the passenger satisfaction sub-section was included in the order from the most satisfaction to the least satisfaction from the perspective of travelers (interactive social communication, comfort in the speed of services, respect for the local context, provision of attraction, art enhancement). The value of enhancing the passenger experience has not been achieved, and the awareness and education among staff has been achieved at an average rate.

5.1.3 Analyzing and measuring economic sustainability

In this paragraph, the term economic sustainability of the application model for Baghdad International Airport's passenger terminal is described and analyzed as follows:

Investment areas are provided as shopping areas, retail and duty-free shops, in addition to restaurants and cafes as shown in 'Figure 14', as well as parking and transportation, as well as the provision of commercial advertising space within the terminal.

- The resources of the mixed-use areas were achieved by banks and exchanges, as well as supporting the national economy by providing labor for domestic energy within the terminal at a medium rate, and support and access to global trade, as well as the making of long-term agreements with specialized operators at a medium rate [33].
- Airline revenue was achieved by increasing flights across a wide range of countries to different destinations, and the use of aircraft parking taxes and fees for different companies, as well as the achievement of other privileges such as payment of passenger fees, flight catering, ground management and fuel-saving [34].

Figure 14. An advertisement, restaurants, cafes and duty-free shops at Baghdad International Airport passenger terminals (Photographed researchers)

6- Conclusions

- The emergence of sustainable passenger terminals is a response to the environmental, technological and social changes of the current era, and the result of the daily number of travellers and

to achieve their satisfaction, and in order to improve the reality of achieving sustainable passenger terminals, the urgent need to redesign or rehabilitate passenger terminals that meet the environmental, psychological and economic reasons, for operators and users.

- In order to obtain international environmental assessment certificates suiting the local climate to reach environmentally sustainable passenger terminals, the required accreditation must be tailored to meet its requirements, whether the design and implementation of a new terminal, operation and maintenance of an existing terminal, or interior design and construction.
- The previous studies and presentations formed the diversity of knowledge associated with the design aspects of sustainable passenger terminals and achieved a basic information base for building a comprehensive theoretical framework for different aspects, which was identified in three main vocabularies: environmental sustainability of passenger terminals in terms of site and transport, site sustainability, water efficiency, conservation of energy and atmosphere, materials and resources, internal environment quality, innovation, regional priority, social sustainability of passenger terminals in terms of passenger satisfaction, awareness and education, and economic sustainability of passenger terminals in terms of providing Investment arenas, and other privileges.
- The results of the application showed that the constructed local passenger terminals achieved some environmental aspects, as well as the requirements of water efficiency and site sustainability with the highest values compared to the other secondary vocabularies results, while the economic sustainability has achieved high values. The results showed the dependence on achieving the airline revenues among other concessions the highest values compared with the other secondary vocabularies results, while the constructed local passenger terminals lack the social dimension of passenger satisfaction.

7- Recommendations

- Any design or rehabilitation of passenger terminals should be done in accordance with the environmental, social and economic aspects of sustainable passenger terminals.
- Developing management and organizational plans and strategies based on the principles of sustainability, identifying priorities, mechanisms and periods required, and operational procedural steps as a first step towards the establishment of a sustainable passenger terminal.
- The necessity of designing, operating and maintaining passenger terminals according to the legal aspects and the design dimensions of sustainable passenger terminals, as well as the necessity of developing operational and administrative practices, and adopting various modern technological developments such as intelligent systems, technologies, building materials, alternative energy sources, etc., to promote sustainable development therein, and spread awareness and education to present and future generations.
- The necessity to review the currently approved designs for operation and maintenance, as well as the new construction at local airports and adjusting them according to the environmental, social and economic aspects of sustainability, to match the requirements of the era associated with the seeking to achieve sustainable development.
- Adopting the satisfaction of passengers as a basis and achieving their interest by making periodic questionnaires for them to promote sustainable development therein, and spreading awareness and education among employees in present and future to improve the quality of life.
- Enhancing the experience of the passengers and enriching them with contemporary treatments and initiatives to achieve the satisfaction of passengers to ensure its achievement in local experiences at higher levels.
- Refer to the foundations, basic designs and treatments of the French executing company, especially with regard to the operational aspect, rehabilitation and maintenance as they achieve the values of sustainability.

References.

[1] Al-Gharawi Q, Abdul Hussein A 2014 Strategies for sustainable environmental design according to local reality *unpublished PHD thesis*, Department of Architecture, University of Technology, p79.(in Arabic language)

[2] ACRP Report 25 2010 *Airport Passenger Terminal Planning and Design* ", Guidebook", Airport Cooperative Research Program; Transportation Research Board; National Academies of Sciences, Engineering, and Medicine **1**, Washington ,pp 62-66.
[3] LEED v4 Updated July 2, 2018, for" *Building Design and Construction* "Addenda , pp 13-33
[4] FAA, U.S. Department of Transportation Federal Aviation Administration,13 july 2018," *Advisory Circular*", Airport Terminal Planning, Chapter 9, Sustainability in Terminal Planning, pp 83-89 .
[5] Babu, Annie Diana, 22nd to 24th October 2008, " *A Low Energy Passenger Terminal Building for Ahmedabad Airport, India: 'Building Envelope as an Environment Regulator*", 25th Conference on Passive and Low Energy Architecture, Dublin, pp 2-7.
[6] Conci, Mira, 2014, "*A Zero Energy terminal building for Amsterdam Airport Schipho*l" Master Architecture, Urbanism and Building Sciences, pp 20-63.
[7] Waheeb, Sahel Abdullah Saadeddine, April 2017, "*The possibility of benefiting from the concepts of sustainability in the future of airport design in Saudi Arabia*", Journal of Umm Al-Qura University for Engineering, Architecture and Computer, **Vol 7**, Issue 2, pp 12-14. (in Arabic language)
[8] Duliński, Wojciech, 2015, "*Sustainable Airport Passenger Terminal Design, the Review of Selected Examples*" , technical transactions, **4-B**, pp. 95-97.
[9] LEED v4, Updated July 2, 2018, for "*Interior Design and Construction*" Addenda, pp 56-60.
[10] LEED v4, Updated January 5, 2018, for "*Building Operations and Maintenance*" Addenda, pp. 56-89.
[11] Wang Z, Zhao H, Lin B, Zhu Y, Yu J, 2015, " *Investigation of indoor environment quality of Chinese large-hub airport terminal buildings through longitudinal field measurement and subjective survey*", Building and Environment , China , pp.18-19
[12] Edwards,Brian , 2005, " *The Modern Airport Terminal: New Approaches to Airport Architecture* ", Second Edition, Taylor & Francis, E & FN Spon, London, p175.
[13] Harrison, Anna, Popovic, Vesna, Kraal, Ben J., & Kleinschmidt, Tristan, 2012 "*Challenges in passenger terminal design : a conceptual model of passenger experience*", In Israsena,Praima, Tangsantikul,Juthamas , & Durling,David (Eds.) Proceedings of the Design Research Society (DRS), pp. 2-3.
[14] Changi Airport Group, 2018 "*Taking Flight The Changi Airport Terminal Story*", Singapore, p. 68-72.
[15] Incheon InternatIonal aIrport Report , 2018 "*smart, art&green airport*" , pp 27-30.
[16] (https://www.archdaily.com/532770/heydar-aliyev-international-airport-baku-autoban).
[17] (https://www.hok.com/design/type/aviation-transportation/hamad-international-airport).
[18] TIAT, Tokyo International Air Terminal, January 21, 2016," *Quality Infrastructure on International Passenger Terminal*", Tokyo International Airport (Haneda)" , pp 2-4.
[19] IAU, March 2018, "Sustainable *Airport Areas*", Guidelines for Decision Makers, île-de-France - Paris Region Urban Planning and Development Agency, pp 71-72 .
[20] Kalinke, Lydia, 2013, "*Innovations in Sustainable Airport Planning Efforts*" A Case Study for Hartsfield-Jackson International Airport, p. 26.
[21] (https://archello.com/project/amsterdam-airport-schiphol-terminal)
[22] The Yearbook, Dubai Airports,2012, p. 23.
[23] Changi Airport Group, CAG, 2016, " *Annual Report*", Singapore , p17.
[24] HKIA, Hong Kong International Airport, 2011, *" buIldInG JOurnAl HOnGKOnG* ", AuGusT ,p31.
[25] Fraport AG, 2016, Visual Fact Book," *Frankfurt Airport*" ,Germany, p. 18.
[26] Sabaa, Khalid Kamel,1990, "*The Foundations and Determinants of Planning and Design of International and Local Airports*", Unpublished Master Thesis, Department of Architecture, College of Engineering, University of Baghdad, pp 79-81. (in Arabic language)
[27] Analyzed by the author based on the attached images and survey, Baghdad airport.

[28] Mahawish, Osama Sabah Mohammed,2012, "*Structural Systems and Expressive Function in Airport Terminal Buildings"*, Unpublished Master Thesis, Department of Architecture, College of Engineering, University of Baghdad, p. 155. (in Arabic language)
[29] Baghdad International Airport, Local Airports Department, 3/7/2019 " *Personal interview with Chief Senior Engineer: Nidaa Majed Amin* ".
[30] Baghdad International Airport, Local Airports Division, 3/7/2019, "*Interview with Senior Engineer: Mustafa Abdul Halim Ali"*.
[31] Baghdad International Airport, Electricity Division, 10/7/2019, `` *Interview with Senior Engineer: Hamid Ibrahim Mohammed* ".
[32] Baghdad International Airport, Airport Administration, 10/7/2019, `` *Interview with Chief Cleaning Supervisors: Salah Hussein Herz "*.
[33] Wages Regulation in Iraqi Civil Airports, June 11, 2018, No. (6) issued by the Council of Ministers Resolution No. (201), Al-Waqa'a Al-Iraqiya Newspaper, Issue No. 4495, Fifty-ninth Year. (in Arabic language)
[34] Baghdad International Airport, Finance Section 2019, *Interview with CFO: Mustafa Kassem Kassara, "*.