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The Sustainability Status of the Present Train Stations

Reham Eldessuky Hamed [1]

[1] Assoc.Prof. Beni-Suef University, Architecture Dep., Faculty of Engineering, Beni Suef, Egypt.

Email: Reham011299@eng.bsu.edu.eg, R_dessuky@yahoo.com, Dr.reham@aucegypt.edu

Abstract: As a result of climate change's effects, the world's eyes are now on green and sustainable railway stations that can also improve operational performance and provide higher rates of protection and security. Accordingly, the current Egyptian development strategy seeks to make progress in environmental protection, energy conservation, ease of use, and cost-effectiveness, particularly with existing and new railway stations. The assessment is conducted to verify the sustainability of railway stations by evaluating economical, social, and environmental strategies and risk assessments to accurately describe the sustainability status and development potential of the railway stations under consideration. The survey to assess the long-term suitability of the proposed railway station includes the Ramses, Giza, and Beni Suef railway stations, three of the most important and most widely used regional railway stations in Egypt, towards the sustainable state of the existing train stations.

Keywords: Climate Change, Global Urban Transition, Sustainable Mobility, Egyptian Railway Station, Sustainable Rating Systems.

1- Introduction

Mobility is an important aspect of city development that contributes to strengthening all aspects of urban life, including the triad of sustainable factors: economic, social, and environmental. Particularly in railway stations, as a massive project that incorporates urban, architectural, structural, technological, environmental, and energy aspects to create embedded properties of the entire urban contextual relationship. Especially during the smart city era, when engineers, architects, and planners face increased challenges as more people travel. Public transportation systems have gradually evolved to meet the criteria of environmentally sustainable development (ESD) and to implement alternatives capable of making cities both sustainably liveable and environmentally friendly [1]. The difficulty of balancing the internal and external environment and providing a profitable economic return at train stations is one of the things that must be taken into account throughout the project life cycle. Global concerns have been raised about the economic, social, and environmental sustainability of railway stations, including criteria for the "barrier effect" and "operational design" of the railway station. Environmental design; energy conservation; architectural design; and the environment, where impact analysis and urban planning have emerged as key success factors [2]. Establish, maintain, and assess the environmental impact, including noise and vibration monitoring; air quality and dust prevention; waste disposal and recycling; site pollution; environmental emergencies; and architectural identity and cultural heritage reflection. whereas regional intervention strategies include sustainable technical applications in existing stations. The establishment of an operating station entails not only a conceptual station and site but also attention to methods of operation as they are linked by an interconnected network of relationships and processes supported by technical and sustainable operational guidelines.

Fig.1. depicts how sustainable transportation has the potential to contribute to the achievement of up to 92% of all sustainable development goals related to transportation and climate change solutions [3].

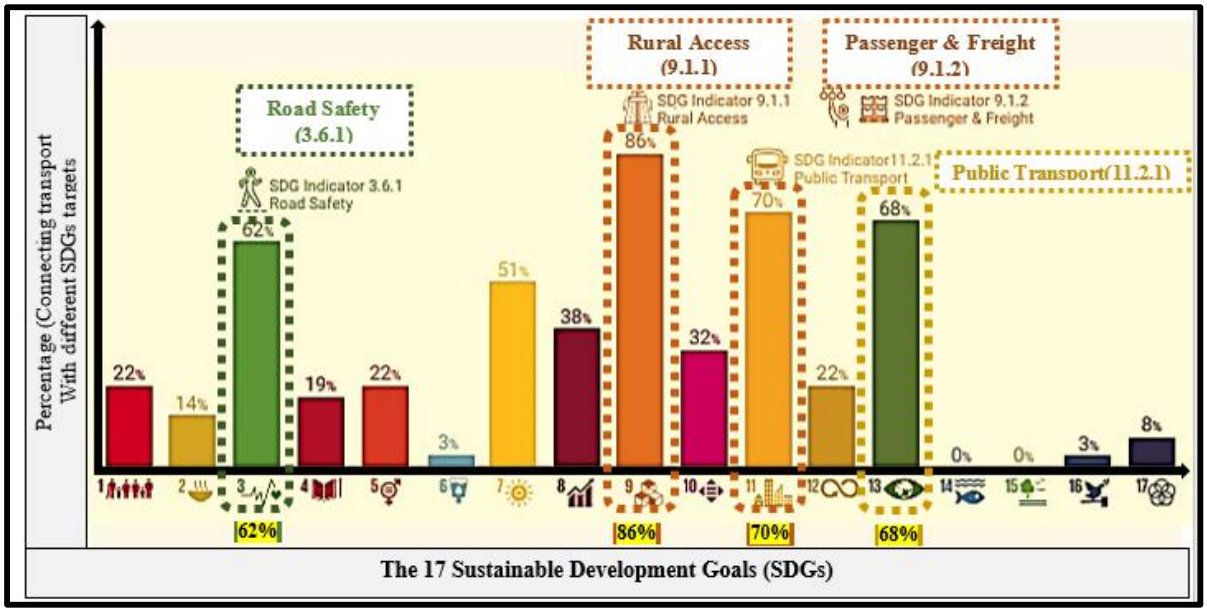


Fig.1: The percentage of Transportation that is directly Related to SDG targets

The current achievements of increasing the number of citizens, supply technology, and information management require implementable mobility systems. At the same time, as one of the primary causes of climate change, the transportation sector contributes significantly to the negative emissions associated with the global warming phenomenon that the world is currently experiencing.

2. Restructuring of National Railways

The world's attention is focused on sustainable railways, which will reduce energy consumption and carbon emissions while also ensuring sustainable urban transportation by activating railway electrical systems to improve efficiency and maintenance, reduce potential breakdowns, and leaves a positive impact on passengers from the ticket office to the departure of the station [4]. It is worth noting that Egypt, after England, is the second country in the world to use railways as a mode of transportation for people and goods, and the first in Africa and the Middle East [5]. Egypt's 2030 vision for transportation and communication ought to be set up to achieve the railways' role in operation and management. While rail transportation is the primary sector that will determine the success of efforts to balance numerous types of transportation, transportation policies are at the heart of economic development as an approach to linking sustainability with development actions. Railroad cooperation in freight transportation will also increase by 20%. According to official information from the Global Co-operation and Planning Ministry, the primary goals for the long-term development of national railway restructuring are industry cooperation, continuous improvement, and infrastructural facilities (Goal 9)[6]. Related objectives are to reduce inequality (Goal 10) and promote environmentally responsible cities and communities (Goal 11) [7]. The government is working to improve railway services, ensure safety, renew railways, and reduce accidents by implementing international safety and security standards, increasing safety factors, and increasing line capacity. As well as providing transportation between counties for Egyptian citizens in all regions.

3-Railway Station Requirements

Train stations with ideal design characteristics provide functionality, performance, satisfaction, and value. Station standards and requirements are classified into urban design and planning, design and function, social and regional, human behavioral, technical requirements, safety, and security, and environmental design standards as follows [8]:

Urban Design and Planning Requirements: promoting urban growth; assisting new communities' formation; establishing green societies; creating city green belts; linking to states of the country; improving urban life; enhancing sustainable achievement; adapting to climate change; and making cities more environmentally conscious.

Design and Functional Requirements: ensuring spatial configuration accessibility within a horizontal and vertical hierarchy; balancing combined form and function attractiveness; allocating service spaces; providing ticket areas; assisting information desks; securing operator spaces; ensuring entrance clarity; providing recreational spaces; adding directional panels; creating internal courtyards, and designing commercial investment spaces are all examples of commercial investment spaces.

Social and Regional Requirements: Promoting social contact, achieving economic efficiency, putting an emphasis on waiting and gathering spaces, respecting cultural heritage, and strengthening regional identity are just a few of the social and regional requirements.

Humans and their Behavior: improving space uniqueness; identifying visibility; illustrating spatial accessibility; improving noise protection; enhancing ventilation and lighting; paying attention to external and internal spaces; expecting human behavior; displaying signs and icons; respecting policies; preserving spaces; committing to societal rights; and reaching safety and security.

Technical Requirements: Providing movement paths, avoiding changing levels, reducing the change of direction, reducing the walking distance, clarifying movement axes, limiting intersections in the corridors, separating the movement, and enhancing visual communication are some of the strategies.

Safety and Security Requirements: controlling entrances and exits; providing checkpoints and security; protecting personal property; supplying emergency requirements; supporting escape axes and ladders; using signs and guiding signs; safeguarding against external conditions; ensuring operational maintenance requirements; providing a fire extinguishing center; and providing a security point inside the station.

Environmental Design Requirements: Using open central courtyards and internal green gardens to reduce operational costs, as well as focusing on the station's open plan system rather than the closed system to provide daylight and purely natural ventilation, applying the use of natural lighting and reducing energy consumption via transparent glass ceilings and facades protected from direct sunlight. Creating open corridors to reduce pollution and cool temperatures inside, establishing rooftop gardens to reduce carbon emissions, and respecting site specifics, privacy, and the area's relationship with the surrounding neighborhoods. Soundproofing, noise abatement, thermal insulation, rainwater collection from the station's roof, and water recycling are all important considerations, in addition to promoting the use of locally sourced, environmentally friendly materials.

4-Sustainable Railway Transportation

Sustainability in railway stations includes the trinity of social, economic, and environmental aspects. Social sustainability is achieved through interaction between users in entertainment venues and service stations; achieving social financial support; community justice; providing aesthetics; being

environmentally friendly; easy access; and ensuring security and safety requirements. Economic sustainability secures movement barriers, activates crisis management, supports balancing between infrastructure and consumer costs, provides statement and rental opportunities for shops, creates an economic exchange within the station, provides employment opportunities, and activates the green economy. Environmental sustainability is achieved by considering pollution impacts, ecological degradation, environmental aspects of the railway station, and energy efficiency to reduce operational costs [9]. Because of climatological change, sustainable development is the innate human need to leave a lasting and positive legacy for the environment and future generations. Therefore, adapting to the climatic, cultural, environmental, technical, and economic aspects of transportation plans in general and railway stations in particular towards the creation of more sustainable railway stations and systems is currently enjoying support on a global scale. Accordingly, there were many methods of evaluating, analyzing, and developing the railways to become more sustainable. However, it is preferable to follow measurable indicators in strategic and long-term management. Green transportation has become synonymous with incorporating sophisticated technology into transportation planning. There are many sustainable transport assessment systems for improving and measuring sustainability to design more sustainable railway stations [10], which are shown in the table. 1. Rating systems for the characteristics of sustainable railway transportation.

Table 1: Characteristics of Sustainable Railway Transportation Rating Systems

Rating Systems	G.R The Green Roads	STARS Sustainable Transport Access Rating System	GLTES Green Leadership Transportation Environmental Sustainability	LAST Liveable Sustainable Transportation	Envision Envision	INVEST Infrastructure Voluntary Evaluation Sustainability Tools	AST Asian sustainable Transport
Project Scale	- Planning - Design -Construction	- Planning - Design -Construction - Life Cycle	- Planning - Design - Operation - Maintenance	- Planning - Design -Construction	- Planning - Design - Operation - Systems - Maintenance	- Planning - Design - Operation - Systems - Maintenance	- Architecture - Economic - Social - Environment - Risk Levels
Scope							
Architecture	Low	Low	Low	Neutral	Moderate	Good	Very strong
Structure	Good	Moderate	Moderate	Neutral	Very strong	Low	Low
Materials	Good	Moderate	Very strong	Moderate	Moderate	Neutral	Neutral
Environmental	Good	Good	Neutral	Very strong	Moderate	Low	Very strong
Accessibility	Good	Very strong	Low	Good	Moderate	Very strong	Very strong
Energy	Moderate	Moderate	Very strong	Moderate	Good	Moderate	Very strong
Value Scale	Low	Neutral	Moderate	Good		Very strong	
Analysis	There are numerous methods for evaluating railway station sustainability, including planning, design, and implementation phases, as well as all phases such as maintenance, operating systems, and life cycle. At the architectural and planning level and its social, environmental, functional, and economic reflection, many evaluation criteria for the sustainability of the railways were not available due to their reliance on the evaluation of the stages of implementation, construction, maintenance, operation, and water recycling. As a result, the Asian assessment model for sustainable transportation is the most related to the studied train stations, urban planning standards, and sustainability assessment scores.						

4-Sustainable Railway Rating System

Determining the optimal evaluation of railway stations depends on the association of evaluation criteria with the stages of urban planning, architectural design, and environmental studies. assessing long-term

viability and being aware of sustainability factors' various strengths and weaknesses and their compatibility with architectural, urban, and environmental requirements. As well as the ease of use by architects, the possibility of partial and total modification of the sustainability criteria, taking into account the level of risk in the classification and choosing the classification closest to the urban, architectural, and environmental factors, the AST rating value is divided into four major levels [11]: the economic, social, and environmental triads are given equal weight, with five parameters each reaching 30%. The remaining 10% of risks are represented by standard ratios of various international classifications in the areas of transportation and sustainability. The economic parameters include user satisfaction; movement and operation; performance and trust; financial overload; and economic benefits. While reaching access, work opportunities, cost affordability, safety and security, social inclusion, and suitability are some of the social parameters. The environmental parameters include emissions, pollution, climate adaptation, the environment, and clean energy. While there are risks in the design, implementation, and operation of sustainability parameters as shown in the following Fig.2.

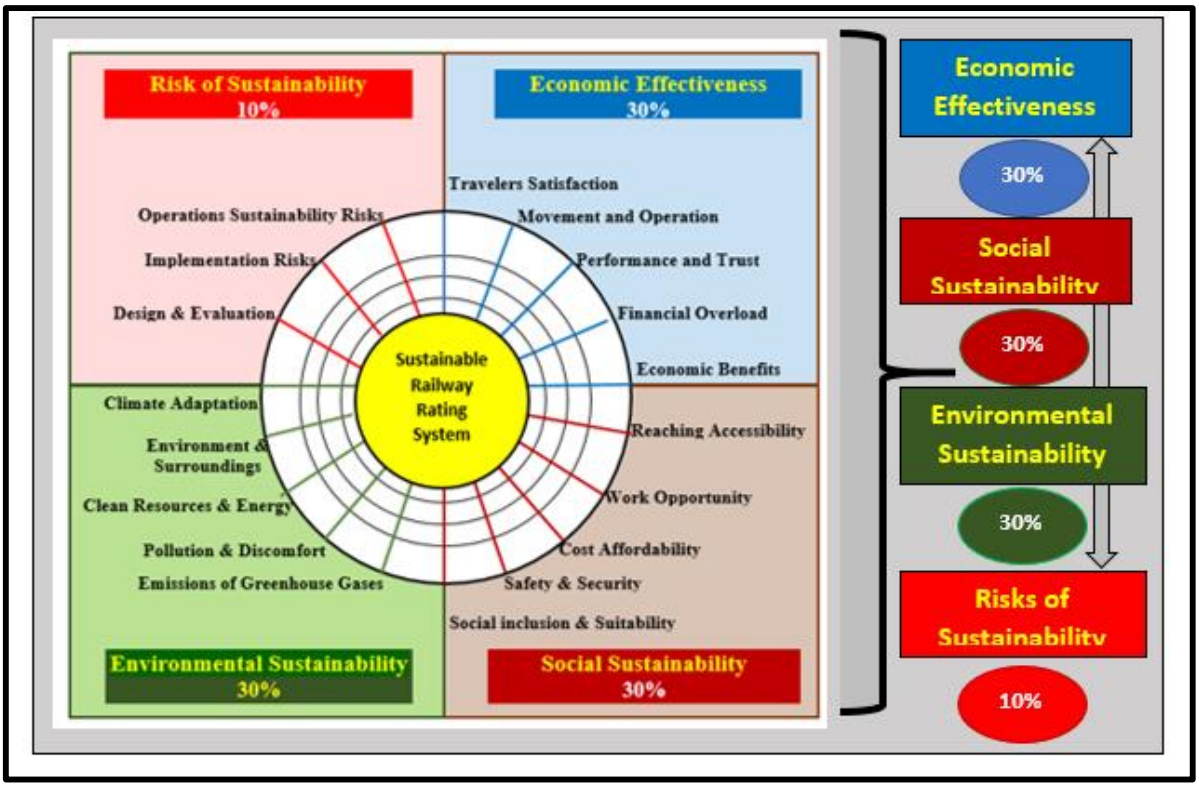


Fig.2. Sustainable Railway Rating parameters

Consequently, the assessment of equal normative effects includes seven levels spanning from (-3) negatively to (3) positively. The measures and effects of linking the magnitude rate and the importance of Trinity's effects on measuring and evaluating the transformation of sustainable transportation are depicted in the table. 2. The rates for evaluating the sustainability of railway stations are represented by the sum of the points for the four parameters as a core criterion for rating. Generally, evaluations are quantifiable and must be based on scientific and professional perceptions. Rating valuable data is used to indicate rail station performance in terms of sustainable performance monitoring and evaluation. The overall assessment of the train station in terms of sustainability is determined by summing the scores of all parameters and comparing the total to the sustainability scale. The ratings for sustainability range from highly sustainable to achieving sustainability, medium sustainable to marginally sustainable, and very unsustainable. To highlight the bottom line, even more, a low-scoring railway station cannot get high marks by any sustainability rating criterion It is beneficial that the

classification refers to the strengths, the possibilities for exploiting them, the weaknesses, and the methods of solution, including cost savings, alternative solutions, possible alternatives, investment benefits, and performance indicators. Table.2. shows that the score is determined from minus one to zero at stations that have negative parameters in general, and so these influences are partially mediated or counterbalanced by positive effects. Besides that, as an outcome of the consequences of prominent risk effects, from minus two to minus four, this rating is for stations whose negative effects outweigh their positive effects or are extremely dangerous. While the railway station's rating is minus 5 or higher, this represents a lack of sustainability potential, which requires a rethink of the project.

Economic Effectiveness Factor - Rating Value system (ECON. RSV)							
Rating	Highly Economically Ineffective	Economically Ineffective	Moderately Economically Ineffective	Marginally Economically Effective	Moderately Economically Effective	Economically Effective	Highly EconomicallyEffective
Score	-3	-2	-1	0	1	2	3
Social Sustainability Factor - Rating Value system (SRSV)							
Rating	Highly Socially Unsustainable	Socially Unsustainable	Moderately Socially Unsustainable	Marginally Socially Inclusive	Moderately Socially Inclusive	Socially Inclusive	Highly Socially Inclusive
Score	-3	-2	-1	0	1	2	3
Environmental Sustainability Factor - Rating Value system (ENV.RSV)							
Rating	Highly Environmentally Unsustainable	Environmentally Unsustainable	Moderately Environmentally Unsustainable	Marginally Environmentally Sustainable	Moderately Environmentally Sustainable	Environmentally Sustainable	Extremely Environmentally Friendly
Score	-3	-2	-1	0	1	2	3
Risk to Long-Term Applicability Factor - Rating Value system (RRSV)							
Rating	Extremely		Extremely with Countermeasures	Middle Rate	Little Rate		
Score	-2		-1	0	1		
Σ Rating Value = Economic Points + Social Points + Environmental Points + Risk Points							

Sustainable Railway Transportation							
Rating	Highly Unsustainable	Unsustainable	Moderately Unsustainable	Marginally Sustainable	Moderately Sustainable	Sustainable	Highly Sustainable
Score	(-5) to (-10)	(-2) to (-4)	(-1) to (zero)	(1) to(2)	(3) to (4)	(5) to (7)	(7) to (10)
Scales	E	D	C	B	B+	A	A+
	Catastrophic	Fail	Close to Fail	Pass	Fair	Good to Very Good	Excellent to Outstanding

Table.2 The AST Sustainable Railway Transportation Rating Values and Levels

RSV		Economic	Social	Environment	Evaluation Scale Value	
Rating Value system (RSV)	3	**Extremely** (Cost Effective + Socially Effective + Environmentally Friendly)			**Extremely Positive**	**Low**
	2	**Efficient** (Cost Efficient + Socially Resilient + Environmentally Friendly)			**Strongly Positive**	
	1	**Moderately** (Cost Efficient + Socially Resilient + Environmentally Friendly)			**Moderately Positive**	
	0	**Neutral** (Cost Efficient + Socially Adaptable+ Environmentally Friendly)			**Neutral/Marginally Positive**	**Moderate**
	-1	**Various** (Not Economically + Socially Modestly Unsustainable +Environmentally Moderately Unsustainable			**Moderately Negative**	**High with Countermeasures**
	-2	**Inefficient** (Incompetent in terms of Cost + Social Failure + Environmental Risk)			**Strongly Negative**	**High**
	-3	**Extremely Inefficient** (Extremely Cost + Socially and Environmentally Risky)			**Very Strongly Negative**	

Relating Magnitude and Significance of Impacts			
Magnitude	**Significance:** Little	Moderate	Many
Small	Neutral	Neutral	Moderate
Moderate	Neutral	Moderate	Strong
Large	Moderate	Strong	Very strong

As a result, the grading system is more suitable for assessing the sustainability and efficiency of good energy conservation in railway stations in Egypt. When the total of the grades is seven or higher, the rating value of stations shows extremely significant positive effects on all parameters, meeting a wide range of criteria for sustainable transportation. The rating, which ranges from five to six, is given to stations that enhance significant parameters across all categories and also many sustainable transportation criteria. While the scale runs from three to four, it is given to stations with ordinarily positive outcomes and reasonable consequences. These effects are either accumulated on one sustainable criterion or of moderate amplitude parameters, or there are some negative risk effects. However, stations with a rating of one to two attract hopeful sustainability criteria even while possessing disadvantageous parameter influences or impactful consequences.

5. Research Methodology

The Egyptian government plans to develop the railway station in many ways to increase infrastructure efficiency. updating and maintaining railroads; developing and supporting fleets of mobile units; and improving power efficiency. In addition to developing new trains, improving safety factors, developing electrical signals, updating speed bumps and central control systems, and developing maintenance workshops [12]. The number of stations of the Egyptian National Railways is 705 stations. There are 22 main stations and 66 central stations. It has already been decided that 47 stations will be upgraded as follows: - (9) first-phase stations; (11) second-phase stations; (11) third-phase stations; and (9) fourth-phase stations. The analytical study deals with three main railway stations in Egypt: Ramses Station, Giza, and Beni Suef. The research sample was selected based on urban, design, and environmental variance. They are currently being developed because they are central stations, which

are the most in-demand and operational, as well as of regional importance. Analytical research is divided into several stages as shown in Figure 5. First, monitoring of economic, social, environmental, and risk factors for sustainability. Then collect the rating points for each item individually to find the strengths and weaknesses, and finally reach the overall sustainability rating.

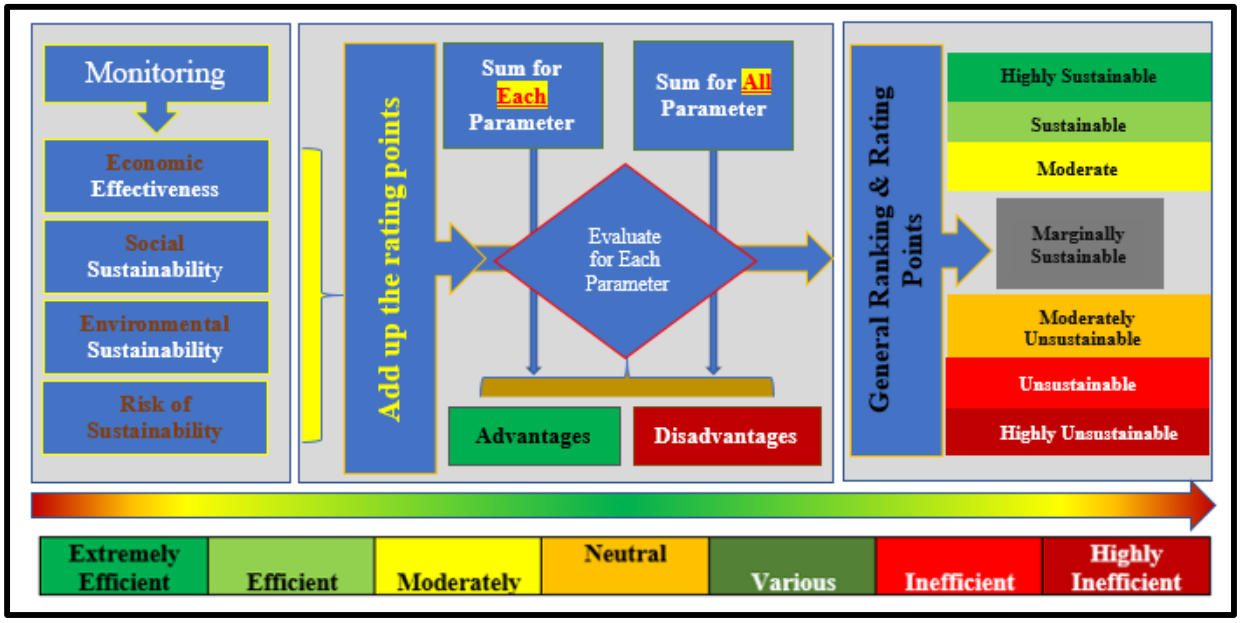


Fig.5. Research Methodology Stages

5. Results and Discussion

The assessment is carried out on a scale to assess sustainability criteria at railway stations, including economic, social, environmental, and risk levels, arriving at a sustainability assessment. Table 3 shows the characteristics data of the railway stations under study The results of the sustainability of the stations under study were reached by faculty members and employees who use trains daily as a means of transportation, as well as by railway employees, and the number of questionnaires and surveys reached nearly three hundred. The results were almost unanimous in the lack of economic, social, and environmental sustainability and protection from risks. All the recommendations were to raise the efficiency of sustainability in the railway sector, given that it represents the daily means of transportation for a large segment of employees in the public and private sectors in Egypt. While the aim is to qualitatively measure the performance of the plant against the sustainable transport targets pursued by the Asian Development Bank and the Department for Transport in the United Kingdom and similar assessment frameworks in New Zealand and Australia. Towards standing for the sustainability of the current train stations and reaching the points of strength and weakness towards activation and assistance in assisting decision-makers, In addition to investigating the identification and classification of levels of sustainable rail transportation to reach strengths, strengthening possibilities, weaknesses, cost-saving methods, possible alternative solutions, investment advantages, and performance indicators.

Table.3. Characteristics of the Rail Stations Under Study

Location	Ramses Railway Station	Giza Railway Station	Beni Suef Railway Station
Case Studies			
No.Trains	288	72	54
Arch.Style	Arabic-Islamic	Pharaonic	Modern
Status	Excellent	Good	Good
Type	Central Railway Station	Main Railway Station	Middle of the Upper Line
Development Stage	Developed and Repurposed	Hugely under Development	Limited Development

The following tables show the tracking of sustainable railway transport levels in the railway stations of Ramses, Giza, and Beni Suef.

5-1- Sustainable Rating Levels of Ramses Rail Station

The most important station in the Egyptian Railways Authority is known as the Misr Station. Trains from most provinces come to it. Many lines depart from it including Upper and Lower Egypt. It underwent a lot of development work, including finishes, services, modernization of directional signs, sidewalks, and trains, and raising safety rates. The construction of an alternative station is currently underway in Bashtil, Giza, and it will be the final station for Upper Egypt trains.

Table.4. **Sustainable Rating Levels of Ramses Rail Station**

Economic Effectiveness	Travelers Satisfaction	There is a high level of user satisfaction concerning the internal development of the station. The development and renovation work at the station includes painting the main building, entrances, and exits of the station. Besides painting the regular and special trains from the outside, renovating the windows, enhancing all signboards, and modifying the cable system at the station. Improving and developing the National Company's shops (kiosks) on the sidewalks, and improving all seats and restrooms at the station. However, the problem of train delays still exists.	Marginally Economically Effective 0 In case of updating the train schedule, the station reaches a moderately economically effective [1]	Moderate Ineffective -2 In the case of activating investments, the station reaches an Economic Effective 1
	Movement and Operation	Carrying out tests for all train stops at the sidewalks; repairing and maintaining screens that display trains' departure times; and lighting all headlights at the station. 255 million pounds, purchasing and supplying new tractors and developing the station, chutes, and infrastructure to increase safety and security. More than 140 billboards create, which consider an effective way to increase revenue.	Marginally Economically Effective 0	
	Performance and Trust	The development and modernization procedures have increased the reliability of the users. However, there is still a complaint about the delay of the trains. as well as		

		operate the first control unit with high-resolution 200-megapixel panoramic cameras distributed at 180 degrees across the station to monitor movement and security discipline	Economically Effective 1	
	Financial Overload	Developing the National Company's shops (kiosks) on the sidewalks, starting to exploit the Ramses Station Mall, attracting significant brands, and opening bank branches. The offices of the employees inside the station move to use as a commercial space to increase the railway's revenues, and the entrances and exits of the station are being diverted to be the paths of the public inside the mall to support the station's commercial activities while increasing them, which is reflected in the facility's revenue.	Moderately Ineffective -2 In the case of activating investments, the station reaches a Marginally Economically Effective [0]	
	Economic Benefits	The railways are suffering from economic loss. Which requires activating investments. The station significantly improves access to a growing positive central of a city.	Moderate Ineffective-2 When activating investments, the station reaches a Moderate Positive [0]	
Social Effectiveness	Reaching Accessibility	Access to departure and arrival points and interior spaces using a lot of signposts, and audio instructions. Progress is generally positive.	Moderately Social Inclusive 1	Marginally Social Inclusive 0 In the case of activating investments, the station reaches Socially Sustainable 1
	Work Opportunity	Moderately positive to moderately negative. There are numerous job opportunities in the case of increasing investments.	Neutral 0 When increasing investments Socially Inclusive [1]	
	Cost Affordability	Transport prices will rise in line with service costs, so common users will benefit from better transportation quality. Transportation services and prices may be impacted.	Socially Unsustainable -2	
	Safety and Security	The development will substantially reduce accidents and resolve many security and safety issues at the station.	Moderately Social Inclusive 1	
	Social inclusion and Suitability	Certain categories of users will benefit from terminal updates that may not meet their most pressing economic needs.	Moderately Social Inclusive 1	
Environmental Sustainability	Emissions of Greenhouse Gases	Moderately positive to moderately negative The development work led to the expansion of the area surrounding the station, forming a separation boundary between the buildings and the surrounding spaces	Moderate Unsustainable-1 In the case of developing [0]	Highly Environmentally Unsustainable -4 In case of development, the station reaches Moderate Environmentally Sustainable
	Pollution and Discomfort		Moderate Unsustainable-1 In the case of developing [0]	
	Clean Resources and Energy	The transition to using electric clean energy is underway. Continuing to waste the available natural resources and not using them through design and implementation.	Moderate Unsustainable -1 In the case of developing [0]	
	Environment and Surroundings	Positive to moderate to negative. The development work will create a boundary between the station and the surrounding spaces, but the buildings need to retrofit to adapt to climate change.	Moderate Unsustainable-1 In the case of developing [0]	
	Climate Adaptation		Neutral 0 In the case of developing [1]	

				1
Risk of Sustainability	Design & Evaluation	Moderately positive to moderately negative. Sustainability risks appear at all stages of design, implementation, and operation, which requires the creation of environmental stations, including buildings, railways, and services to convert the station into a positively rated station.	Medium 0	Medium Risk of Sustainability 0
	Implementation Risks		Medium 0	
	Operations Sustainability Risks		Medium 0	

Positive results from the station classification can effectively outweigh negative results for some criteria. However, it is generally an unsustainable train station, so it requires ecological architectural solutions to ensure an improved rating over the life of the project. This is achieved by making modifications to buildings, railways, and services to convert the station into a positively rated station. While the negative consequences can be addressed by improving the performance of the railway power design, On an economic level, the railway stations are losing out as one of the service projects, which requires resorting to investments, especially in the field of energy management. As for the social level, it tends to be sustainable in a positive way, as the negative effects are amenable to improvement. On the contrary, on an environmental level, it is not completely sustainable, and there are some very strong negative effects. Also, the level of risk is considered medium, and it is expected to occur at different levels of risk.

Table.5. Ramses Rail Station General Ranking and Rating Points

Rating Levels	General Ranking - Rating Points		Development Possibilities	
Economic Effectiveness	Moderate Ineffective	**-2**	Economic Effective	1-3
Social Sustainability	Marginally Social Inclusive	**0**	Modirate Social Inclusive	1-2
Env. Sustainability	Highly Env. Unsustainable	**-4**	Moderate Env. Sustainable	0-1
Risk of Sustainability	Medium Risk of Sustainability	**0**	Medium Risk of Sustainability	0-1
Total	Unsustainable **-2**		**Sustainable (2-6)**	

5-2- Sustainable Rating Levels of Giza Rail Station

It is one of the main and vital stations, as it has been repaired, developed, and modernized as part of the current investment plan to develop the railway sector, including trains, stations, signals, bumps, and sidewalks. as well as improving the train station's surroundings, improving sidewalk efficiency, beautifying them, planning streets, and creating green spaces.

Table.6. Sustainable Rating Levels of Giza Rail Station

Economic Effectiveness	Travelers Satisfaction	The station is undergoing renovations to increase its efficiency while preserving its architectural identity. Some trains are delayed by at least two hours, and improvement work includes adding station platforms, raising efficiency, and keeping the architectural style. Bashtil railway station is also being constructed to relieve pressure on the main old stations to serve travelers from Upper Egypt, Bahri, and Al-Manashy, which has made a noticeable change in the extent of traveler satisfaction.	Moderate Economic Ineffective -1 In the case of running Bashtil station, the station will reach a moderately economically effective [0]	Highly Economical Ineffective -6 In the case of activating Bashtil station investments, the station reaches an

	Movement and Operation	The development work includes the repair and modernization of trains and stations, signals and bumps, and the paving of the entrance. 80% of the improvement works have been completed. The development work includes repairing and modern modernizing transitions, signals, bumps, and entrance paving. 80% of the optimization work has been completed. While the Bashtil train station, which is currently under construction, includes workshops, garages, warehouses, and maintenance because it is a smart station, it achieves efficient performance and the highest levels of security and safety.	Marginally Economically Effective 0 In the case of running Bashtil station, the station will reach anEconomically Effective [1]	Economic Effective 2
	Performance and Trust	Since other means of transportation are out of schedule, unsafe, or only available periodically, the quality and reliability of transportation will only improve with the continuous updates of some customers. Specifically, the arrival time of Bashtil Station and the railway sector's electric trains.	Marginally Economically Effective 0 In the case of running Bashtil station, the station will reach an Economically Effective [1]	
	Financial Overload	The management's ability to invest greatly reduces the share of government funding, which will have a long-term impact on other important development requirements. While the investment opportunities will increase upon opening the Bashtil train station, which includes commercial centers, investment stores, commercial and residential administrative buildings, bank branches, and agencies, this also provides the necessary funding to operate the station.	Moderately Ineffective -2 In the case of activating Bashtil investments, the station will reach a Marginally Economically Effective [0]	
	Economic Benefits	While financial markets will expand with the opening of the Bashtil train station, which includes advertising hubs, financial shops, residential and business buildings, bank branch offices, and organizations that provide the required financial assistance to operate the station, the station also greatly improves significant exposure to an overwhelmingly positive center for the region.	Highly Economical Ineffective -3 When activating Bashtil station investments, the station reaches a Moderate Positive [0]	
	Reaching Accessibility	Train users' ability to gain access to basic services. The progress is generally positive. Increasing the ability of users to access basic services,in general , seems reasonable. However, due to a large number of trains and travel directions, it is necessary to increase the number of pedestrian tunnels and guiding signs.	Moderate Social Ineffective -1 When opening Bashtil station, the station will reach Moderately Social Inclusive 1	
Social Effectiveness	Work Opportunity	It is currently in a moderately negative range. in the case of operating the Bashtil station to jobs and stimulate the rail sector, particularly in the Giza region, and especially to stimulate economic growth.	Neutral 0 When increasing Bashtil investments Socially Inclusive [2]	Moderate Social Inclusive -1

	Cost Affordability	Transfer prices will increase in line with the costs of the service, so regular users will benefit from better transfer quality. Transportation services and prices may be affected. When Bashtil station is operational, the level of service and investment rates may be self-sufficient and cover the costs of supporting eligible passengers.	Socially Unsustainable -2 When increasing Bashtil investments Socially Inclusive [1]	In the case of activating Bashtil station, the station will reach Socially Sustainable 6
	Safety and Security	Trains, stations, signals, bumps, and sidewalks have all been repaired, developed, and transformed to improve the station's operational efficiency.	Moderately Social Inclusive 1	
	Social inclusion and Suitability	Some of the affected multiple users will benefit from the station upgrade, but it may not meet their most pressing economic needs. Bashtil station, on the other hand, will create jobs, stimulate development, attract investments, and provide financing as Upper Egypt's gateway by subsidizing the cost of transportation for travelers.	Moderately Social Inclusive 1	
Environmental Sustainability	Emissions of Greenhouse Gases	It turns out to be negative due to the station's location in a populated housing area, as the station's walls are surrounded by residential buildings. This necessitates expanding the buildings, including the station, and establishing a dividing line between the buildings and the surrounding spaces.	Unsustainable-3 In the case of development, It will become [-2]	Highly Environmentally Unsustainable -12 In case of development, the station reaches Highly Environmentally Unsustainable-5
	Pollution and Discomfort		Unsustainable-3 In the case of development, It will become [-2]	
	Clean Resources and Energy	The transition to using electric clean energy is underway. Continuing to waste the available natural resources and not using them through design and implementation.	Unsustainable-3 In the case of development, It will become [0]	
	Environment and Surroundings	Positive to moderate to negative. The development work will create a boundary between the station and the surrounding spaces, but the buildings need to retrofit to adapt to climate change.	Unsustainable-3 In the case of development, It will become [-2]	
	Climate Adaptation		Neutral 0 In the case of developing [1]	
Risk of Sustainability	Design & Evaluation	It turns out to be negative, as long-term risks emerge as a result of the station's presence in a vital, densely populated region that is difficult to remove. Accordingly, it necessitates the construction of environmental stations, including buildings, rail, and services, to improve the station's rating.	Risk -1	Moderate Risk of Sustainability -2 In case of development, the station reaches Medium 0
	Implementation Risks		Risk -1	
	Operations Sustainability Risks		Medium 0	

Despite the approaching opening date of Bashtil train station, which positively impacts the station's efficiency, the station's presence in a residential area harms all sectors. This necessitates total reliance on Bashtil Station and finding solutions for its expansion around Giza Train Station, particularly the buildings located at the station walls, to reduce environmental, social, and economic risks and make the station more sustainable. The station's location in a residential area harmed all levels of sustainability. This necessitates complete reliance on Bashtel station and the development of

environmental solutions for the area surrounding the Giza train station, particularly the buildings on the station walls, so that the station becomes environmentally friendly through rehabilitation of the station area, the use of electric trains, and increased security and safety rates to reduce sustainability risks.

Table.7. Giza Rail Station General Ranking and Rating Points

Rating Levels	General Ranking - Rating Points		Development Possibilities	
Economic Effectiveness	Highly Economical Ineffective	**-6**	Economic Effective	0-2
Social Sustainability	Moderate Social Inclusive	**-1**	Socially Sustainable	2-6
Env. Sustainability	Highly Env. Unsustainable	**-12**	Highly Env. Unsustainable	-5
Risk of Sustainability	Moderate Risk	**-2**	Medium Risk of Sustainability	-1-0
Total	Highly Unsustainable **-21**		**Unsustainable to Sustainable (-4 - 3)**	

5-3- Sustainable Rating Levels of Beni Suef Rail Station

It is one of the main stations in Upper Egypt's central region.

The signal systems have been improved, the electronic control system has been upgraded, bumps and slides have been created, and new stations have been launched.

Table.8. **Sustainable Rating Values of Beni Suef Rail Station**

Economic Effectiveness	Travelers Satisfaction	Trains are running at least two hours late, especially those from Upper Egypt, negatively influencing passenger satisfaction. However, the work of developing signaling pathway systems, switching to central control strategies, developing bumps, and launching new stations has a positive impact on satisfying travelers and increasing station efficiency.	Moderate Economic Ineffective -1 In the case of running Bashtil station, the station will reach a moderately economically effective [0]	Highly Economical Ineffective -8 In the case of activating Bashtil station investments, the station reaches an Economic Ineffective -2
	Movement and Operation	The development work includes signaling systems, the transition of the electronic control system, and the establishment of a new station.	Marginally Economically Effective 0	
	Performance and Trust	Compared to other modes of transportation, trains distinguish by their schedule and safety. Due to the development of signaling systems and the transformation of control systems into electronic solutions, passenger reliability has increased, which requires many continuous updates to increase the station's efficiency and reliability rates.	Moderate Economic Ineffective -1 In the case of development solutions, the station will reach an Economically Effective [0]	
	Financial Overload	There are no suggestions for investment opportunities, renting shops and cafeterias, or exploiting the surrounding buildings to cover the costs, which requires placing the station in the strategic plan for development and investments.	Highly Economic Ineffective-3 In the case of Create investments, the station will reach a Moderate Economically Effective [-1]	

	Economic Benefits	The station significantly improves access to the city. Nevertheless, there is a lot of opportunity to attract investment. In addition to investing in restaurants, cafeterias, and phone and appliance repair shops, most of the travelers are employees.	Highly Economical Ineffective -3 In the case of Create investments, the station will reach a Moderate Economically Effective [-1]	
	Reaching Accessibility	Due to the small size of the station and the expansion of platforms, the opportunity to access basic services is a positive step forward. In the case of opening new stations, more signs are needed and horizontal and vertical circulation solutions are required for easy access in all station zones.	Moderate Social Ineffective 0 When the platforms are expanded, the station will reach Moderately Social Inclusive [1]	Socially Unsustainable -2 In the case of activating investments, the station will reach Socially Sustainable 5
	Work Opportunity	Moderately positive to moderately negative. In the case of opening new stations and increasing the rate of investment, new job opportunities will be available to stimulate the economic growth of the Upper Egypt Gate.	Moderate Social effective 0 When opening new stations and increasing investments, the station will reach Socially Inclusive [2]	
	Cost Affordability	Transport prices will rise in line with service costs, so common users will benefit from better transportation quality. Transportation services and prices may be impacted.	Socially Unsustainable -3 When increasing investments, the station will reach Socially Inclusive [1]	
	Safety and Security	The development of signal systems, as well as the shift to electronic shift systems and other station developments, has greatly reduced accidents and provided security and safety in the station.	Moderately Social Inclusive 1	
	Social inclusion and Suitability	Supporting the cost of low-income travelers, requires stimulating investments, promotion, and marketing to attract investments that create job opportunities and achieve economic and social progress. The station may not meet their most urgent economic needs.	Moderately Social Inclusive 0 When increasing investments, the station will reach Socially Inclusive [1]	
Environmental Sustainability	Emissions of Greenhouse Gases	It turns out to be negative due to the station's location in a populated housing area, as residential buildings surround the station's walls. This necessitates expanding the buildings, including the station, and establishing a dividing line between the buildings and the surrounding spaces.	Unsustainable -2 In the case of development, It will become [-1]	Highly Environmentally Unsustainable -7 In case of development, the station reaches Environmentally Unsustainable-1
	Pollution and Discomfort		Unsustainable -1 In the case of development, It will become [-1]	
	Clean Resources and Energy	The transition to using electric clean energy is underway. Continuing to waste the available natural resources and not using them through design and implementation.	Unsustainable -3 In the case of development, It will become [0]	
	Environment and Surroundings	Positive to moderate to negative. The development work will create a boundary between the station and the surrounding	Unsustainable -1 In the case of development, It will become [0]	

	Climate Adaptation	spaces, but the buildings need to retrofit to adapt to climate change.	Neutral 0 In the case of developing [1]	
Risk of Sustainability	Design & Evaluation	It turned out to be negative because there are abandoned residential buildings overlooking the station. However, the urban surroundings of the station currently develop according to the governorate's strategic plan. In general, it entails the construction of environmental stations, including buildings, rail, and services, to improve station classification.	Risk -1 In the case of development, It will become[0]	Moderate Risk of Sustainability -2 In case of development, the station reaches Medium 0
	Implementation Risks		Risk -1 In the case of development, It will become[0]	
	Operations Sustainability Risks		Medium 0	

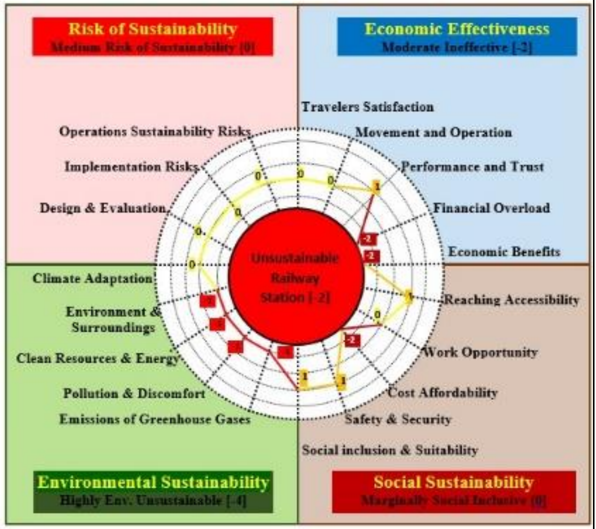
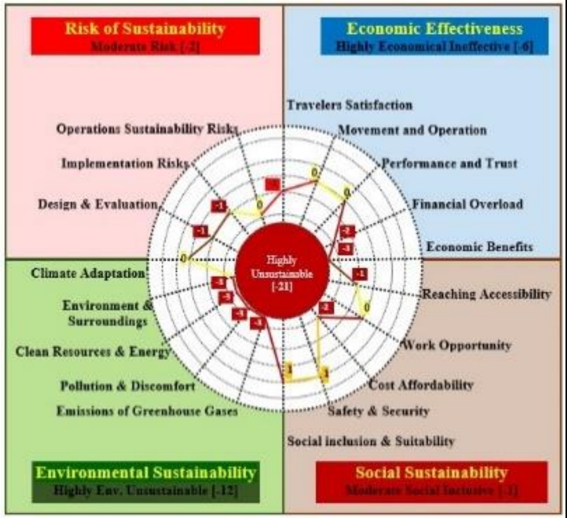
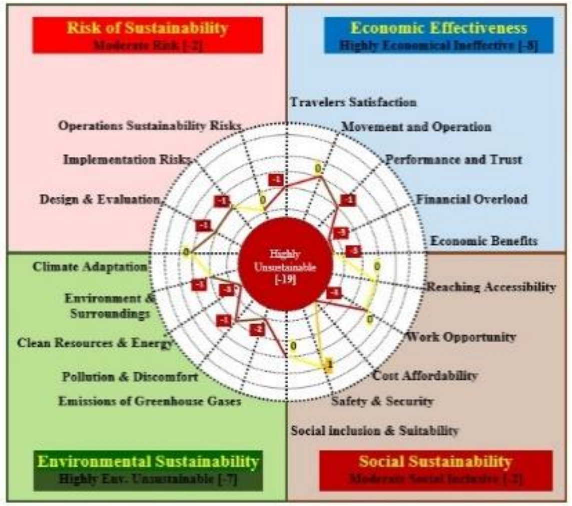
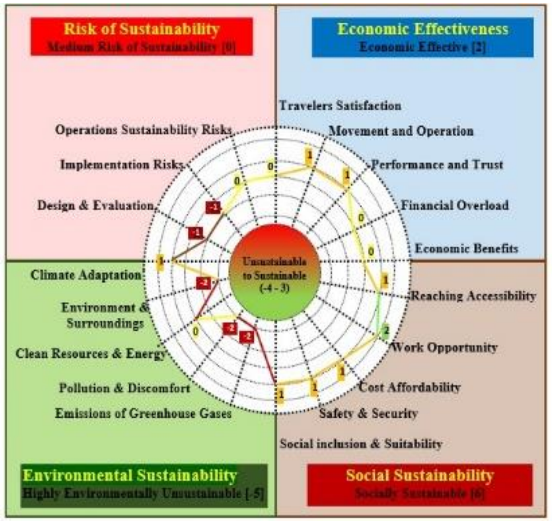
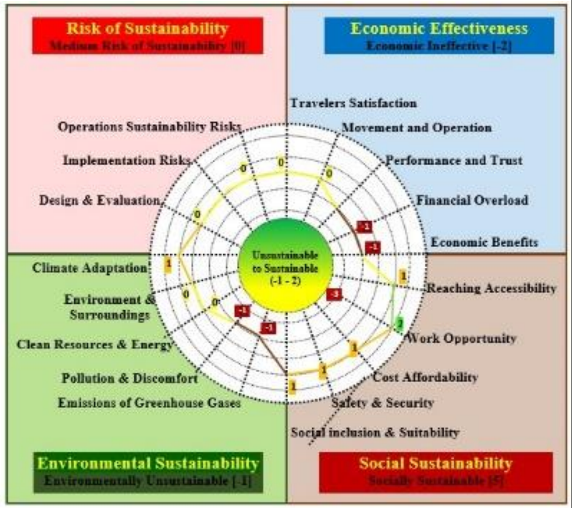
Beni Suef station is generally an unsustainable train station, so it requires ecological architectural solutions to ensure rating optimization over the life of the project. This is achieved by making modifications to buildings, railways, and services to convert the station into a positively rated station. While severe negative consequences can be remedied by enhancing railway energy design performance. On the economic level, railway stations are wasteful compared to the service provided, which requires resorting to investments, especially in the field of energy management. As for the social level, it tends to be sustainable in a positive way as the negative effects are subject to improvement. On the contrary, on the environmental level, it is not completely sustainable and there are some very strong negative effects. The level of risk becomes medium and is expected to occur at various levels of risk as shown in table 9.

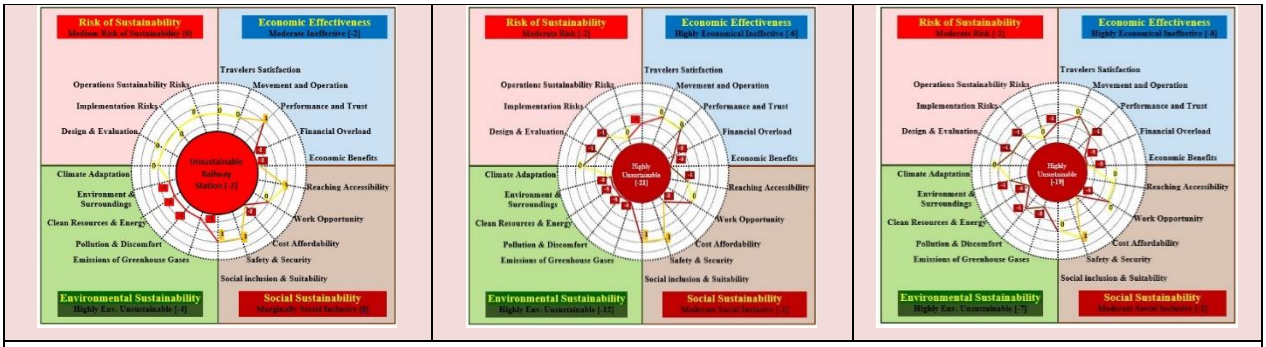
Table.9. Beni Suef Rail Station General Ranking and Rating Points

Rating Levels	General Ranking - Rating Points		Development Possibilities	
Economic Effectiveness	Highly Economical Ineffective	**-8**	Economic Ineffective	-2
Social Sustainability	Moderate Social Inclusive	**-2**	Socially Sustainable	2-5
Env. Sustainability	Highly Env. Unsustainable	**-7**	Highly Env. Unsustainable	-1
Risk of Sustainability	Moderate Risk	**-2**	Medium Risk of Sustainability	0
Total	Highly Unsustainable **-19**		**Unsustainable to Sustainable (-1 - 2)**	

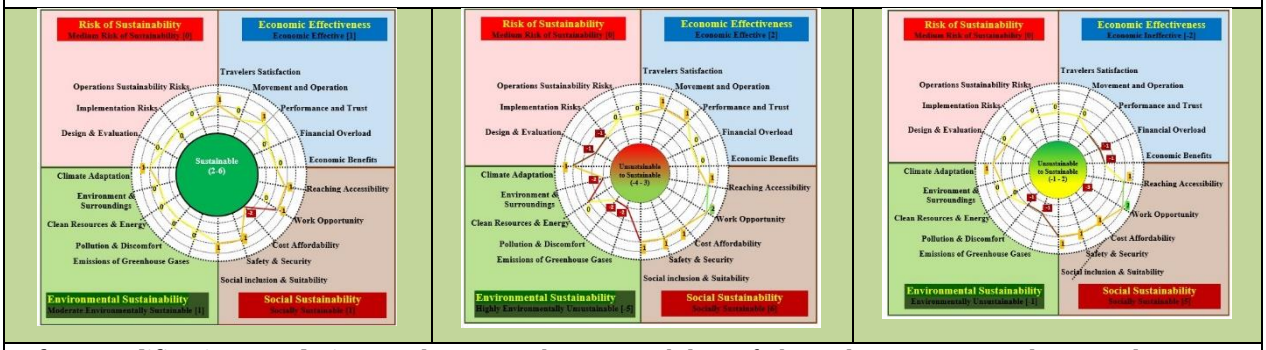
Table 10 shows the comparative analysis of Ramses, Giza, and Beni Suef, three of Egypt's most significant railway stations, conducted to determine the sustainability of the railway station under consideration. Environmental and economic degradation pose a significant threat because of extremely negative impacts with critical and long-term consequences. This necessarily requires the investigation of comprehensive management strategies to find environmental solutions with economic returns. Towards a framework for sustainable railway stations, which requires long-term investments to meet recent climate challenges through socio-economic development, environmentally friendly response, and development cooperation.

Table.10. the comparative analysis of Ramses, Giza, and Beni Suef railway stations

Ramses Railway Station	**Ramses Railway Station (Base Case)**	**Ramses Railway Station (Base Case)**	**Ramses Railway Station (Base Case)**
Giza Railway Station			
	Ramses Railway Station (After Modifications)	**Ramses Railway Station (After Modifications)**	**Ramses Railway Station After Modifications)**
Beni Suef Railway Station			



Base case Analysis: The positive results from the Ramses station's rating can effectively outweigh the negative results for some criteria. While the negative effects can be mitigated by improving the performance of railway energy design, railway stations suffer economically as one of the service projects requiring investments, particularly in the field of energy management. In terms of the social level, it tends to be positive and sustainable because the negative effects are subject to improvement. On the contrary, it is not entirely sustainable from an environmental standpoint, and there are some significant negative consequences. Furthermore, the level of risk is considered medium, and it is expected to occur at various levels of risk. Notwithstanding the approaching opening date of Bashtil train station, which benefits Giza station's efficiency, the station's presence in a residential area harms all sectors. This necessitates total reliance on Bashtil Station and finding solutions for its expansion around Giza Train Station, particularly the buildings located at the station walls, to reduce environmental, social, and economic risks and make the station more sustainable. Beni Suef station is generally regarded as an unsustainable train station, particularly from an economic standpoint, because railway stations are regarded as waste compared to the service provided, necessitating investments, particularly in the field of energy management. In terms of the social level, it tends to be positive and sustainable because the negative effects are subject to improvement. On the contrary, it is not entirely sustainable from an environmental standpoint, and there are some significant negative consequences. The risk level rises to medium and is expected to occur at various risk levels. In general, all the train stations under study are not sustainable, so they require environmental architectural solutions to ensure classification improvement over the life of the project. This is achieved by making modifications to the buildings, rail, and services to transform the station into a positively rated station.



After Modification Analysis: To determine the sustainability of the railway station under consideration, a comparative analysis of Ramses, Giza, and Beni Suef, three of Egypt's most important railway stations was conducted. Environmental and economic degradation pose a significant threat due to their extremely negative impacts and their critical and long-term consequences. Overall, none of the train stations under consideration are sustainable, necessitating environmental architectural solutions to ensure classification improvement over the project's life. This is accomplished by modifying the station's buildings, rail, and services to make it a positively rated station. This necessitates the investigation of comprehensive management strategies to find environmental solutions with economic returns. To create a framework for sustainable railway stations, long-term investments in socioeconomic development, environmentally friendly responses, and development cooperation are required. This necessitates total reliance on the Bashtel station as well as the development of environmental solutions to make the stations environmentally friendly through rehabilitation, the use of electric trains, and increased levels of security and safety to reduce sustainability risks. Railroad stations suffer economically because they are one of the service projects that require investments, particularly in the field of energy management. This is reflected in economic, social, and environmental factors as well as reduced sustainability risk.

References

[1] Ogryzek, M., Adamska-Kmieć, D. and Klimach, A., 2020. Sustainable transport: an efficient transportation network—case study. Sustainability, 12(19), p.8274.

[2] Azhgaliyeva, D. and Rahut, D.B., 2022. Promoting Green Buildings: Barriers, Solutions, and Policies.

[3] UN. Sustainable Transport, Sustainable Development. Interagency Report for Second Global Sustainable Transport Conference 2021 (pp. 1-120). San Francisco, CA, USA: United Nations.

[4] van Hagen, M. and van Oort, N., 2019. Improving railway passengers experience: two perspectives. Journal of Traffic and Transportation Engineering, 7(3), pp.2328-2142.

[5] ElDin, A.B., Megahed, I. and Attia, H., 2020. Digital Transformation and Cybersecurity Governance Case 1: Egypt Post from a Legacy Platform to Digitally-Driven Organization Case 2: Egypt National Railways: ICT Can Save Egyptian Lives.

[6] Egyptian National Railways. News Details. (n.d.). Retrieved October 22, 2022, from https://www.enr.gov.eg/En/NewsDetails.aspx?NewsID=1352

[7] Ministry of International Cooperation - Egypt National Railways Restructuring Project (RRP). (n.d.). Retrieved October 22, 2022, from https://moic.gov.eg/project/231

[8] Chong, C.T., 2011. Sustainable Railway Development Through Careful Planning, Design, and Implementation. Editorial Team, 26.

[9] Santos, J., Bressi, S., Cerezo, V., & Presti, D. L. (2018, October). SUP&R DST: SUstainable pavement & railways decision support tool. In 6th International Symposium on Life-Cycle Civil Engineering, IALCCE 2018; Ghent; Belgium; 28 October 2018 through 31 October 2018.

[10] Szpotowicz, R., & Tóth, C. (2020). Revision of sustainable road rating systems: Selection of the best-suited system for Hungarian road construction using the topics method. Sustainability, 12(21), 8884.

[11] Sakamoto, K., 2014. Toward a sustainability appraisal framework for transport.

[12] Egyptian National Railways. (n.d.). Egyptian National Railways (ENR. Egyptian National Railways. Retrieved October 29, 2022, from https://www.enr.gov.eg/En/ENR.aspx?ID=2