



Developing the Role of the Local Aviation Sector in the Sustainable Development of Nineveh Governorate

N K A Shahwan  

Department of Accounting Techniques, College of Administrative Technologies, Alnoor University, Mosul, 41012, Iraq

Article information

Article history:

Received: 28 May 2025
Revised: 2 June 2025
Accepted: 1 July 2025

Keywords:

Domestic aviation
Sustainable development
national GDP
Economic growth
Nineveh

Correspondence:

Nawfal Kasim Ali Shahwan
nawfal.kasim@alnoor.edu.iq

Abstract

This paper aims to study the development of the role of the local aviation sector in sustainable development in Nineveh Province. The aviation sector is a driver of global communication and economic growth. It faces challenges related to carbon emissions and energy efficiency, in addition to environmental and regulatory pressures. Attempts to integrate energy into aviation infrastructure promote sustainable energy and resource efficiency. Based on recent case studies of Mosul International Airport and Al-Sahaji International Airport (West Mosul) for the next 30 years, we hope to formulate solutions for the local aviation sector that serve sustainable development goals.

The number of passengers in Mosul reached half a million after one year of operation, and revenues reached approximately \$3.6 billion. On the empirical side, the curves are upward, and all variables have a statistically significant impact on growth. The aviation sector in Nineveh will be a significant contributor to the national GDP.

The adoption of renewable energy and modern resource management contributes to build a sustainable development future for Iraq and consolidates the role of the aviation sector. It contributes to achieving Sustainable Development Goals 9, 8, and 13: industry and infrastructure, decent work and economic growth, and climate action. Finally, Goal 10 aims to reduce inequality between rural and urban areas.

DOI: <https://doi.org/10.69513/jdifas.v1.i0.a1> , ©Authors, 2025, College of Administrative Techniques, Alnoor University.
This is an open access article under the CC BY 4.0 license (<http://creativecommons.org/licenses/by/4.0/>).

Introduction

This study aims to develop the role of the domestic aviation sector in sustainable development in Nineveh Province. This sector can contribute to stimulating growth for Nineveh Province and Iraq. It contributes to revitalizing foreign and domestic trade, enhancing tourism, and creating job opportunities (1). This sector relies on renewable energy, facilitates the use of resources, and contributes to economic growth. It faces significant challenges related to sustainability, improving energy efficiency, and addressing environmental impacts. The aviation sector must achieve sustainable development goals and development (2). It assumes that economic and social developing the role of the domestic aviation sector in sustainable development lies in managing economic

resources and supporting sustainable development goals.

The paper highlights the economic and environmental status of domestic aviation in Iraq, citing a case study of Mosul Airport after its reconstruction in 2025 and the feasibility of constructing Al-Sahaji International Airport over the next decade to understand local challenges and opportunities. The economic cost of transitioning to clean energy in Iraq requires an analysis of regulatory impacts on sustainability, addressing sustainability challenges, and technological advancements in the field of sustainable aviation in post-conflict areas, a case study of Mosul.

From recent case studies on Mosul International Airport (3) and Al-Sahaji International Airport (4) west Mosul, for the next thirties, we envision

formulating solutions for the local aviation sector that serve sustainable development goals. This sector is important for economic development and has numerous tasks that span all economic and administrative sectors. Developing this airport sector creates jobs and business opportunities in the fields of aviation, logistics, and hospitality, which can be addressed economically, environmentally, technologically, security-tourism-related, and culturally.

The National Development Plan 2024-2028 emphasizes the importance of developing Iraq's infrastructure, particularly air services (5). Mosul International Airport employees have trained through an intensive training program on modern navigation systems (6). The aviation sector must contribute to achieving sustainable development goals, rely on the increased use of renewable energy, and play a role in allocating economic resources. Therefore, the next paragraph discusses its importance in managing economic resources, and the second paragraph discusses its development in support of the sustainable development goals. The third paragraph provides a quantitative analysis of the role of the local aviation sector and a discussion of the results to formulate development proposals.

1. Aviation Sector and Resource Utilization

Developing the role of the aviation sector in sustainable development of Nineveh, the province that emerged from the three-year ISIS domination (2014-2016), necessarily includes managing economic resources and developing its contribution to economic growth (7), with the aim of providing recommendations.

1.1. Objectives and Resource Management

The aviation sector has two roles in resource utilization, better resource management and improved operational efficiency. The former includes human resource management, aviation safety and security, and improved financial sustainability (8). The latter involves supporting trade and investment, promoting tourism and domestic air transport, and achieving some sustainable development goals.

1.1.1. Better Resource Management

It includes human resource management, improving aviation safety and security, and improving financial sustainability.

A- Human resource management and providing job opportunities, such as training and qualifying local cadres to support the aviation sector, reducing dependence on foreign labor, creating new job opportunities, aviation logistics and maintenance, and encouraging research and development in aviation to promote innovation and develop local technologies.

B- Aviation safety and security, which includes modernizing aviation safety systems by adopting artificial intelligence technologies in flight control, improving risk management to ensure the continuity of

efficient and safe air operations, and enhancing international cooperation with relevant organizations such as the International Civil Aviation Organization (ICAO) to ensure compliance with international standards.

C- Improving the financial sustainability of airports and airlines, which includes diversifying revenue sources through the development of commercial services within airports such as duty-free shops and hotels. Strengthening public-private investment partnerships to develop infrastructure and increase revenues, and implementing effective financial policies to reduce debt and increase profitability for airlines and airports.

1.1.2. Enhancing economic and operational efficiency

This refers to reducing operational costs (fuel, maintenance, and smart technology) to support trade and investment, increasing the efficiency of air transport capacity to promote tourism and domestic air transport, improving scheduling and maximizing aircraft capacity to achieve sustainable development in the aviation sector (9).

A- Supporting trade and investment, including enhancing city and economic zone connectivity to facilitate the movement of goods and services, stimulating local and international investment by improving the aviation sector and attracting airlines and investors, and improving the air cargo sector to support export and agricultural industries and reduce transportation costs.

B- Promoting tourism and domestic air transport, which requires stimulating local and international tourism by providing direct flights at competitive prices, developing passenger services and improving the travel experience to increase passenger demand for domestic flights, and improving air connectivity between Iraqi Provinces to support the local economy and reduce reliance on land transport.

C- Achieving sustainable development in the aviation sector, by developing environmentally friendly aviation solutions, with sustainable fuel and renewable energy in airport operations, implementing energy management strategies to reduce consumption of natural resources and improve operational sustainability, and reducing carbon emissions by modernizing aircraft fleets and adopting more efficient operation practices.

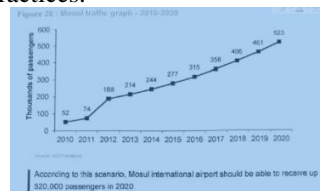


Figure 1: Natural growth of air traffic at Mosul Airport 2010-2020 (Thousands of passengers)
Source: (Shahwan 2022), on Behalf.

1.2. Developing it and enhancing its contribution to economic growth.

The aviation sector is a key driver of economic growth, contributing to the promotion of trade, stimulating tourism, creating job opportunities, and improving logistics services. The following are strategic proposals for developing the aviation sector and achieving a positive impact on the local economy, as noted in (Map 1).

1.2.1. Developing the aviation sector's infrastructure.

This includes (10):

A. Modernizing and expanding local airports, such as rehabilitating Mosul International Airport to increase its capacity and improve passenger services; establishing integrated logistics zones near the airport to support air cargo and trade; and improving air navigation systems and technological infrastructure to increase operational efficiency Note (Map 1).

B. Improving air connectivity between cities: This necessarily includes launching regular domestic flights at competitive prices between Mosul and other Iraqi Provinces, strengthening cooperation with regional and international airlines to provide direct flights to major economic cities, and providing facilities for low-cost carriers to attract passengers and increase the number of flights.

1.2.2. Promoting Investment and Partnerships in the Aviation Sector

The number of passengers expected to reach half a million by 2020, had it not been for the ISIS occupation of Mosul in 2014 (Figure 1). The growth of the aviation sector through partnerships for sustainable development in aviation (11) includes, on the one hand, attracting local and foreign investment: This includes launching public-private partnership (PPP) projects to develop airports and air services. It also includes providing investment incentives such as tax exemptions and financial facilities for investors in the aviation sector, and encouraging international companies to establish maintenance and training centers in Mosul to support the local aviation industry. On the other hand, it supports the air cargo sector, which includes developing an advanced air cargo center at Mosul Airport to support agricultural and industrial exports. It also provides customs facilities and encourages companies to use air cargo as a faster means of transporting products. It also enhances the integration of air transport with land and sea transport to create a sophisticated logistics network.

1.2.3. Developing the workforce and promoting innovation

This includes establishing specialized aviation training centers and supporting research and development in the aviation sector (12). Establishing specialized aviation training centers, including launching training

academies for pilots, aviation engineers, and ground staff, will then implemented. Educational programs will offered at local universities in cooperation with international airlines. Civil aviation training will be encouraged and artificial intelligence technologies will used in flight management. Supporting research and development in the aviation sector will implemented in several tracks, including investing in sustainable aviation technologies such as biofuels and electric aircraft. Initiatives will also launched to support innovation in aviation through technology incubators and start-up support programs. The use of artificial intelligence and the Internet of Things (IoT) must be encouraged to improve the passenger experience and manage air operations..

1.2.4. Promoting domestic tourism and air transport, in two directions

In two directions: stimulating tourism through the aviation sector and improving the passenger experience at airports (13). Stimulating tourism through the aviation sector involves launching promotional campaigns for Mosul as a global tourist destination through airlines, organizing special flights for religious and historical tourism to support the local economy, and offering integrated tourism packages that include airline tickets, accommodation, and sightseeing tours. Improving the passenger experience at airports involves developing the infrastructure for passenger services such as lounges, restaurants, and digital services. This includes introducing electronic reservation systems and artificial intelligence to improve the efficiency of check-in and check-out, along with providing facilities for travelers such as discounted flights for families and students.

1.2.5. Achieving sustainability and reducing environmental impact

This can achieve with the use of renewable energy in the aviation sector, such as developing solar power plants at airports to reduce conventional electricity consumption, encouraging the use of biofuel in aircraft to reduce carbon emissions, and launching waste management initiatives to reduce the consumption of natural resources at airports. This can also achieved through improving aviation policies in accordance with environmental standards, cooperating with international aviation organizations such as ICAO and IATA to follow environmental best practices, developing carbon offset strategies through afforestation and environmental responsibility programs, and incentivizing companies to reduce fuel consumption by improving flight efficiency and modern technologies (14).



Map 1: Aerial photo of the new Mosul Airport. (Showing the scope of expansion for the length of the runway from the geographical south (right on the map) to exceed 3,000 meters). Source: <https://www.pinterest.com/pin/827395762788865559/>

2. Supporting sustainable development goals and renewable energy uses

The sector's development comes through its support for sustainable development goals. This support requires proposals, which discussed in the next paragraph. Development, on the other hand, achieved through its use of renewable energy, and the proposed approaches may be useful.

2.1. Sustainable Development Goals

This section analyzes the development of the aviation sector's role in supporting the Sustainable Development Goals and outlines proposals for its use of renewable energy based on proposed approaches (15). The aviation sector in Mosul, through the reconstruction and reconstruction of Mosul International Airport and, for example, the future construction of Al-Sahaji Airport after a decade represents an opportunity to contribute to sustainable development in Nineveh Province. The renewal of aviation requires a set of proposals that can contribute to achieving the Sustainable Development Goals (SDGs) set by the United Nations, as follow (16) (17).

2.1.1. Strengthening sustainable infrastructure

(Goal 9: Industry, Innovation, and Infrastructure).

Here, Mosul Airport should be rehabilitated and modernized according to modern environmental standards to reduce carbon emissions, taking into account: the use of renewable energy in airport operations, such as solar power-to-power facilities; the development of modern navigation systems based on smart technology to enhance aviation safety and operational efficiency (18).

2.1.2. Supporting the local economy and providing job opportunities

(Goal 8: Decent work and economic growth).

This requires encouraging investment in the aviation sector by offering incentives to local and foreign companies, establishing economic and logistics zones

around the airport to support trade and industries related to air travel, and training local cadres in the fields of aviation, maintenance, and air services to create sustainable jobs.

2.1.3. Promoting environmental sustainability and reducing negative impacts

(Goal 13: Climate Action).

This achieved by using sustainable aviation fuel (SAF) in flights to reduce carbon emissions; (a) recycling and waste management within the airport in accordance with environmental best practices; and (b) establishing green spaces within and around the airport to absorb pollution and enhance environmental aesthetics.

2.1.4. Improving connectivity and transportation to promote development

(Goal 11: Sustainable cities and communities).

This includes: (a) Enhancing air connectivity between Mosul and other Provinces and international cities to attract investment and tourism; (b) Improving public transportation to and from the airport using environmentally friendly electric vehicles, (c) Developing advanced air cargo services to support trade and agricultural and industrial exports.

2.1.5. Promoting cultural tourism and cultural exchange

(Goal 4: Quality education, Goal 8: Sustainable economy).

This means (a) promoting tourism in Nineveh with direct flights connecting Mosul to tourist areas in Iraq; (b) This means launching cultural and educational exchange programs in cooperation with international universities and institutes; (c) Stimulating religious and historical tourism by facilitating visitor access to archaeological sites.

2.1.6. Improving aviation safety and security

(Goal 16: Peace, Justice, and Strong Institutions)

This means modernizing security and surveillance systems to ensure a safe environment for passengers and companies operating at the airport, while strengthening cooperation with international organizations such as the International Civil Aviation Organization (ICAO) to ensure compliance with global aviation standards. This will then include introducing smart systems to detect threats and ensure the safety of passengers and cargo.

2.1.7. Strengthening partnerships for sustainable development

(Goal 17: Partnerships for the Goals).

This includes engaging the private sector in airport development through long-term investment partnerships, collaborating with environmental and economic organizations to achieve more sustainable aviation practices, and establishing partnerships with regional and international airlines to increase flight numbers and stimulate the economy.

2.2. Its uses of renewable energy.

The use of renewable energy in the aviation sector is an important proposal to achieve sustainability and reduce environmental impacts. This proposal can be integrated into Mosul International Airport, and later Al-Sahhaji Airport through several key approaches. It includes the use of solar energy; biofuels; wind energy (that requires it); geothermal heating and cooling systems; electrification of aviation services; and smart energy management, both for the newly built Mosul International Airport and for the planned Al-Sahhaji Airport after 2030, located in the Al-Sahhaji area, 20 km west of Mosul. It features large areas of solar energy (Map 2), as follows (19):

2.2.1. Solar Energy for Airport Operation

This includes installing solar panels on the roofs of airport buildings and aircraft stands to generate the electricity needed to operate facilities; establishing a dedicated solar power plant for the airport to reduce reliance on the national grid and reduce carbon emissions; and providing solar-powered airport runway lighting via LED lights powered by renewable energy. This modernization of energy use will: reduce conventional fuel consumption; reduce long-term operating costs; and enhance the sustainability of the airport's infrastructure.

The use of biofuel in aircraft includes (20) .

A. Introducing sustainable aviation fuel (SAF), made from organic waste and recycled oils, to reduce aircraft emissions.

B. Developing local biofuel production projects in partnership with universities and research centers in Iraq.

C. Encouraging airlines to adopt a biofuel blend on their flights to and from Mosul.

The results include:

A. Reducing carbon dioxide emissions by up to 80%.

B. Improving air quality in the areas surrounding the airport.

C. Supporting the local economy through biofuel production.

2.2.2. Use of geothermal heating and cooling systems

This means applying geothermal energy systems to use the earth's heat to heat airport buildings during the winter and cool them in the summer; integrating these systems into the new airport infrastructure during modernization projects; and providing alternative energy sources for maintenance and management operations within the airport. These applications achieve reducing conventional energy consumption, operating, maintenance costs, and improving energy efficiency within the airport.

2.2.3. Electrification of aviation ground services

By converting ground vehicles within the airport (such as baggage trucks and passenger buses) to solar-powered electricity. Installing electric charging stations

for future electric and hybrid aircraft. Reducing the use of fossil fuel generators by relying on renewable energy systems, which achieves:

A. Reducing carbon emissions from ground vehicles.

B. Reducing noise within the airport environment.

C. Improving the efficiency of transportation operations and services.

2.2.4. Establishing a Smart Airport Energy Management System

Developing a smart system to monitor energy consumption and connect renewable energy sources to operational systems, integrating artificial intelligence technologies to efficiently manage solar and wind power distribution, and analyzing energy data to detect waste and improve energy performance. These steps will: increase energy efficiency within the airport, reduce electricity loss, improve operational sustainability, and enhance the ability to adapt to changes in energy demand.

2.2.5. Wind energy to support airport operations. This includes

Including (a) Establishing small wind turbines near the airport to harness wind power for electricity generation. (b) Studying the feasibility of building wind farms in nearby open areas to support the operation of air facilities. (c) Integrating wind and solar energy to provide renewable energy around the clock. (d) These measures, taken together, will provide an additional energy source for operating support systems, enhance the airport's energy independence, and support the local electricity grid with a clean and sustainable source.



Map 2: An aerial photo of the Nineveh International Airport construction site, 20 km west of Mosul, in Al-Sahhaji, Al-Mahalabiya district, to the right of the Tigris River

3. Quantitative Analysis of the Role of the Domestic Aviation Sector

From previous data on the development of the domestic aviation sector in Nineveh Province, particularly in Mosul, it found that it had witnessed remarkable development in recent years, prior to its cessation before ISIS entered the city between 2014 and 2017.

Expected Frequency	Route
3 flights per week (Tuesday, Thursday, and Saturday), with the frequency increasing to daily after 3 months	Mosul - Baghdad
Two flights per week (Wednesday and Friday), with the possibility of increasing based on demand	Mosul - Erbil
One weekly flight, subject to increase or adjustment based on passenger traffic	Mosul - Istanbul

This focus placed on the rehabilitation of Mosul International Airport after the severe damage it sustained, resulting in 70% destruction. (21)

3.1. Key Statistics and Developments

3.1.1. Airport Rehabilitation Completion Rate

By November 2024, the Mosul Airport rehabilitation project had reached 86% completion, with the airport expected to open in 2025.

3.1.2. Increasing Passenger Capacity

The annual passenger capacity is expected to increase from 50,000 to 500,000 after the airport's opening (22).

3.1.3. Infrastructure Improvements

The runway has extended to 3,000 meters, and 11 new facilities have built, including departure and arrival lounges, VIP facilities, a health center, and a 32-meter-tall control tower.

A- Technical Upgrades: The airport has been equipped with modern equipment, previously unused in Iraq, from Italian, French, Norwegian, and German manufacturers. These include advanced radars, navigational lighting systems, and ground lighting. The expected number of passengers is half a million, and the opening is imminent (23). The implementing companies are Turkish, such as 77 and TAV, in addition to international consulting firms such as Hartz, Key Club, and Cellcom.

B- Expected Impact: The opening of Mosul International Airport expected to contribute to strengthening the local aviation sector and facilitating travel. For citizens, and to stimulate economic and tourism activity in Nineveh Province. To date, no final official list of airline carriers and their frequencies has issued following the opening of Mosul International Airport, scheduled for June 10, 2025. However, based on official statements and indications from the airlines themselves, the initial picture can summarized as follows (Table 1):

C- Iraqi Airways: The Governor of Nineveh announced that the first civilian flights after the landing of the Prime Minister's plane will operated by the national carrier immediately after the airport's opening on June 10, 2025.

D- Fly Baghdad: As a private Iraqi airline headquartered in Baghdad and operating 13 domestic and international destinations, it expected to add the Mosul-Baghdad and Mosul-Erbil routes to its network as part of its domestic expansion plans.

C- Turkish Airlines: This Co. has created a booking page for flights to Mosul, indicating its intention to launch the Istanbul-Mosul service once the airport receives the necessary security classification.

Table 1: Initial schedules (subject to change)

These frequencies are preliminary, based on an estimated initial operating schedule. Exact details (departure and arrival times, ticket prices) will be officially determined after the airlines' schedules published. It recommended follow the Ministry of Transport's website, "the Iraqi Civil Aviation Authority, CAA" and the carriers' official social media accounts for the latest updates.

An estimated growth chart for the number of passengers (in thousands) and monthly revenues (millions of dollars) at Mosul International Airport during the first 12 months after opening (June 2025–May 2026). The forecast based on a gradual increase in demand, with an average revenue of approximately \$70 per passenger.

A. The airport starts with approximately 20,000 passengers in the first month, reaching more than 400,000 by the twelfth month.

B. Revenues increase from \$1.4 million to approximately \$29.4 million per month during the same period. These figures are estimates and simplified to illustrate the general trend. Assumptions (such as average ticket price or passenger growth rate) can adjusted to represent other scenarios or incorporate actual data as it becomes available. These frequencies are preliminary, based on an estimated initial operating schedule. Exact details (departure and arrival times, ticket prices) will be officially determined after the airlines' schedules published. It recommended follow the Ministry of Transport's website, the Iraqi Civil Aviation Authority, and the carriers' official social media accounts for the latest updates.

An estimated growth chart for the number of passengers (in thousands) and monthly revenues (millions of dollars) at Mosul International Airport during the first 12 months opening (June 2025 – May 2026). The forecast based on a gradual increase in demand, with an average revenue of approximately \$70 per passenger.

A. The airport starts with approximately 20,000 passengers in the first month, reaching more than 400,000 by the twelfth month.

B. Revenues increase from \$1.4 million to approximately \$29.4 million per month during the same period. These figures are estimates and simplified to illustrate the general trend. Assumptions (such as average ticket price or passenger growth rate) can adjusted to represent other scenarios or incorporate actual data as it becomes available.

3.2. A simple mathematical model is proposed.

Sustainable Development Goal 8 emphasizes decent work and economic growth. The domestic aviation sector, according to the study's hypothesis, contributes

to job creation and strengthening the local economy through aviation services. The airport's monthly revenues also linked to the main factors influencing them, with variables and estimates explained. This study examines this goal for the role of the aviation sector in economic growth.

3.2.1. Linear Model (Multiple Regression)

We assume that monthly Revenues (R) move linearly with the number of passengers, cargo weight, number of flights, and non-operational activities (retail, parking, etc.):

$$R = \beta_0 + \beta_1 P + \beta_2 C + \beta_3 F + \beta_4 S + u \quad (1)$$

R: Monthly revenue (million dollars)

P: Number of passengers per month (thousand passengers)

C: Freight volume carried (tons)

F: Number of flights (landings and takeoffs)

S: Non-operating service revenue (e.g., retail, parking, shop rent, etc.) (Million dollars)

β_0 : Constant (fixed "base" revenues)

β_1, \dots, β_4 : Regression coefficients (sensitivity of revenue per unit of each variable)

u: Random error

Scaling and calibration: This involves collecting historical monthly data on R, P, C, F, and S, using the ordinary least squares (OLS) method to estimate β_i , and testing the model's quality using R2 statistics and p-values for the coefficients.

3.2.2. Double exponential model (Cobb-Douglas)

Assuming the effects of factors are proportional (with constant growth rates), we use the Cobb-Douglas formula:

$$R = A P^\alpha C^\beta F^\gamma S^\delta \quad (2)$$

$$\ln R = \ln A + \alpha \ln P + \beta \ln C + \gamma \ln F + \delta \ln S \quad (3)$$

Where:

A is the production function constant

$\alpha, \beta, \gamma,$ and δ are elasticities of returns to change in each of the variables, as defined previously.

The estimate linearized using logarithms:

$$\ln R = \ln A + \alpha \ln P + \beta \ln C + \gamma \ln F + \delta \ln S + u \quad (4)$$

3.2.3. Detail other factors (optional)

A. Average ticket price T

Passenger revenue $R = P \times T$

B. Freight tariff κ

Here, revenue R from freight $R = C \times \kappa$

C. Landing and takeoff fees L:

R from fees = $F \times L$

D. Ground services revenue G (platforms, gates, etc. G)

C. Ancillary services S (parking, retail, advertising S)

In this case, it can written as:

$$R = P T + C \kappa + F L + G + S \quad (5)$$

Where:

P: Number of passengers (in thousands)

C: Cargo volume (in tons)

F: Number of flights (landings + takeoffs)

S: Non-operating services revenue (millions of dollars)

R: Estimated monthly revenue (millions of dollars), calculated using a linear model.

The following steps are used:

A. Collect historical data for each variable on a monthly basis.

B. Select a model (linear vs. exponential).

C. Estimate the coefficients statistically.

D. Validate the model (residuals tests, adjustments, and scenarios).

Display the hypothetical data table for the factors (number of passengers, cargo volume, number of flights, non-operating services revenue) and monthly revenues, in order to estimate the multiple linear regression model using the ordinary least squares (OLS) method, as shown in (Table 2).

3.3. Standard Estimation Results

$$R = \beta_0 + 0.0024 P + 0.00019 C + 0.105 F + \beta_4 S + u \quad (6)$$

A. Passenger regression coefficient $\beta_1 \approx 0.0024$: Every 1,000 additional passengers increases revenue by approximately \$2.4 million.

B. Freight coefficient β_2 is relatively small, and services coefficient β_4 shows an effect, but with a lower confidence level (p-value) and a higher confidence level.

C. Number coefficient $\beta_3 \approx 0.105$: Each additional flight increases revenue by approximately \$0.105 million.

D. $R^2 = 90.0\%$ indicates almost perfect agreement with the hypothetical data (expected when using a pre-specified model).

The estimates based on proposed data. When applying the model to actual data, one should ensure that there is no severe multicollinearity and examine the residuals for independence and normal distribution. Then, modify the model or add additional variables as necessary.

3.3.1. Cobb-Douglas Model Summary (Log-Linear)

$$\ln R = \ln A + 0.64 \ln P + 0.15 \ln C + 0.62 \ln F + 0.02 \ln S + u \quad (7)$$

A. Estimated Elasticities:

1) $\alpha \approx 0.64$ for passengers: This means that every 1% relative increase in the number of passengers increases revenue by approximately 0.64%.

2) $\beta \approx 0.15$ for freight (not included in the estimation above, but is part of the model).

3) $\gamma \approx 0.62$ for the number of flights: Every 1% increase in flights increases revenue by approximately 0.62%.

4) $\delta \approx 0.02$ for non-operating services: This effect is small and not statistically significant.

B. $R^2 \approx 90.0\%$ (due to the nature of the assumed data). The number of passengers, along with the number of flights, services, and freight, is significant in its statistical impact and increases financial revenues. The number of passengers after one year of operation reaches half a million, with revenues reaching approximately \$300 million per month. It will reach

approximately \$3 billion by the end of the first year, and the trends are positive. With technological development, the local aviation sector in Nineveh Province continues to be a major contributor to the national GDP. With economic, security, social, historical, environmental, and technological transformations increasingly moving toward sustainable economic development, the development of the local aviation sector is at the heart of the development (Figure 1).

Table 2: Default data in the modeling (for the period from June 2025 to May 2026

Month	No. passengers (thousands)	Cargo volume (tons)	Number of flights	Non-operating services (millions of dollars)	Revenues (millions of dollars) per month
June 2025	20	200	100	0.5	16.998
July 2025	30	300	140	0.7	23.481
August 2025	40	400	180	1.0	30.824
September 2025	55	550	250	1.5	42.762
October 2025	70	700	320	2.0	53.383
November 2025	90	900	410	2.8	68.583
January 2025	120	1200	540	3.8	91.490
January 2025	160	1600	680	5.0	116.884
January 2026	210	2100	850	6.5	148.015
February 2026	270	2700	1060	8.5	187.521
March 2026	340	3400	1340	11.0	236.268
April 2026	420	4200	1680	14.0	294.767

This data can be used to re-estimate models (linear or Cobb-Douglas) or to test alternative scenarios. If you also want logarithmic data or a CSV file to download, please follow these steps. The generated CSV file includes the full dataset for the period from June 2025 to May 2026 and contains the following columns:

- A. Month: Name of the month (June 2025 to May 2026).
- B. P: Number of passengers per month (in thousands).
- C. C: Volume of cargo carried (in tons).
- D. F: Number of flights (landings and takeoffs) per month.
- E. S: Non-operating service revenue (millions of dollars).
- F. R: Estimated monthly revenue from all the above factors (millions of dollars).
- G. ln.P, ln.C, ln.F, ln.S, ln.R are the natural logarithm (ln) of each variable of P, C, F, S, and R, respectively. These are useful when constructing a Cobb-Douglas

model or any analysis that uses logarithmic transformation.

From a data file in Excel, Libre, Office, Calc, or from statistical analysis software Minitab, they can be used directly in estimating models or conducting additional analyses (Table 3).

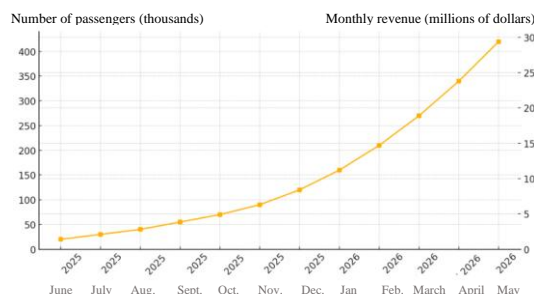
ln_R	ln_S	ln_F	ln_C	ln_P	R	S	F	C	P	Month
2.833117	-0.69315	4.60517	5.298317	2.995732	16.99836	0.5	100	200	20	6-2025
3.156186	-0.35667	4.941642	5.703782	3.401197	23.48087	0.7	140	300	30	7-2025
3.428289	0	5.192957	5.991465	3.688879	30.82384	1	180	400	40	8-2025
3.755639	0.405465	5.521461	6.309918	4.007333	42.76151	1.5	250	550	55	9-2025
3.977491	0.693147	5.768321	6.55108	4.248495	53.38292	2	320	700	70	10-2025
4.228044	1.029619	6.016157	6.802395	4.49981	68.58293	2.8	410	900	90	11-2025
4.516225	1.335001	6.291569	7.090077	4.787492	91.48961	3.8	540	1200	120	12-2025
4.76118	1.609438	6.522093	7.377759	5.075174	116.8837	5	680	1600	160	1-2026
4.997315	1.871802	6.745236	7.649693	5.347108	148.0153	6.5	850	2100	210	2-2026
5.233892	2.140066	6.966024	7.901007	5.598422	187.5213	8.5	1060	2700	270	3-2026
5.464968	2.397895	7.200425	8.131531	5.828946	236.2683	11	1340	3400	340	4-2026
5.686186	2.639057	7.426549	8.34284	6.040255	294.7671	14	1680	4200	420	5-2026

3.3.2. Analysis

The Cobb-Douglas model is useful for understanding the sensitivity (elasticity) of each variable in terms of percentages. It is suitable for analyzing long-term growth and conducting "what-if" analyses of varying growth rates. Suggested next steps:

- A) Use actual data in 2026 for true calibration after the airport begins operating on June 10, 2025.
- B) Test for multicollinearity and reduce it through the selection of independent variables.
- C) Compare the performance of the direct linear regression model against the Cobb-Douglas model in terms of prediction and accuracy.
- D) Add additional variables (such as seasonal conditions, airfares, etc.) to enhance the model.

Figure 1: Projected passenger growth and monthly revenue growth for Mosul International Airport



Conclusion

The aviation sector, a key driver of global connectivity and economic growth, faces significant challenges, ranging from carbon emissions and energy inefficiency to environmental and regulatory pressures. This is achieved by exploring the integration of sustainable energy into aviation infrastructure and enhancing resource efficiency. Along with technological innovation, and by analyzing case studies such as Mosul International Airport, we are developing

solutions for the local sector that align with broader sustainability goals. Adopting renewable energy, resource management, and economic growth strategies also contribute to building a more sustainable future for Iraq by establishing the aviation sector as a model industry for sustainability and aligning technological advancements with environmental management and economic resilience.

The local aviation sector will be a key pillar in driving economic development in Nineveh Province. By modernizing infrastructure, encouraging investment, promoting tourism, and improving logistics services, the Province can become a major economic and tourism hub in Iraq. These steps require collaboration between the government and the private sector, as well as clear strategies to ensure sustainable growth in this sector. The following conclusions can draw from the paper's discussions. It will be a major driver of sustainable development by improving infrastructure, creating jobs, supporting tourism, reducing environmental impact, and enhancing international cooperation. Implementing these proposals will contribute to making Mosul a major economic and logistics hub in Iraq and enhance the achievement of the Sustainable Development Goals (SDGs) in the region.

Renewable energy in Mosul's aviation sector contributes to reducing emissions, improving operational efficiency, and reducing costs in the long term. By implementing projects such as solar power plants, biofuels, geothermal energy, and electrification of ground services, Mosul Airport can become a model of sustainability in Iraq, supporting economic and environmental development in the region.

Four main pathways through which the local aviation sector contributes directly to the development of Nineveh Province through its contributions to the Sustainable Development Goals (SDGs), in order of priority:

Goal 9/Industry, Innovation, and Infrastructure. It enhances infrastructure and economic growth by facilitating transport, trade, and communications. Examples include:

1. Adopting modern aviation technologies, such as clean-fuel aircraft or emission-reducing technologies.
2. Supporting innovation and strengthening infrastructure.
3. Developing quality airports and facilities contributes to improving transportation and facilitating trade and tourism.

Goal 8/ Decent Work and Economic Growth: Contributes to job creation and strengthening the local economy through aviation services. Example:

4. Direct jobs (pilots, engineers, airport workers) and indirect jobs (logistics services, tourism).

5. Facilitates access for tourists and businesspeople, supporting the local economy and increasing national income.

Goal 13/ Climate Action: Can contribute to reducing the carbon footprint through the adoption of environmentally friendly technologies and more efficient operations. Example:

6. Adopting fuel-efficient aircraft and exploring environmentally friendly alternatives contributes to reducing carbon emissions.

7. Environmental initiatives encourage reducing emissions and relying on clean energy sources.

Goal 10/ Reducing Inequality: Facilitates access to remote and border areas, contributing to reducing disparities in development opportunities. Example:

8. It contributes to connecting remote or isolated areas and facilitating access to health, education, and job opportunities, thus reducing development disparities.

By achieving these goals, the aviation sector will become a key component in achieving sustainable economic growth, improving resource management efficiency, and supporting comprehensive development. Success in this regard depends on investment in technology, infrastructure development, and enhancing cooperation between the government and the private sector to ensure a sustainable future for the aviation sector.

From an empirical perspective, all variables, such as passenger numbers, cargo volume, and the number of flights with non-operational services, have a positive statistical impact on increasing monthly financial revenues. After one year of operation, the number of passengers reaches half a million, with revenues reaching approximately \$300 million per month, or approximately \$3.6 billion by the end of the first year. The curves are positive upward. With continued technological development, as mentioned in the second section, domestic aviation in Nineveh Province remains a primary contributor to the national GDP. In line with these trends of economic growth, economic, security, social, historical, environmental, and technological trends are increasingly shifting towards sustainable economic development, driven by the development of the domestic aviation sector in Nineveh Province.

References

1. International Civil Aviation Organization (ICAO). (2025). *Economic development of air transport*. <https://www.icao.int/sustainability/Pages/default.aspx>; <https://www.icao.int/about-icao/aviation-development/pages/sdg.aspx>
2. United Nations Development Programme (UNDP). (2025). *What are the Sustainable Development Goals?* <https://www.undp.org/sustainable-development-goals>
3. Shahwan, N. K. A. (2022). Reconstruction of Mosul International Airport: Obstacles and opportunities for economic development. *Journal of Research in Educational, Human Sciences, Literature and Languages*, 3(4), 199–235. <https://doi.org/11/6/2022>

4. Shahwan, N. K. A. (2023). Establishing Al-Sahaji International Airport in Nineveh Governorate: A study of economic feasibility. *Journal of Regional Studies*, 17(55), 317–358. https://regs.mosuljournals.com/article_176670.html
5. Iraqi Ministry of Planning. (2025). *National Development Plan 2024–2028*. <https://www.facebook.com/photo.php?fbid=1056408796523861&id=100064642514045&set=a.484119160419497>
6. State Company for Airports and Air Navigation Management. (2024, October 29). *Training Mosul International Airport employees according to an intensive training program on modern navigation systems*.
7. Zaki, F. (2024, January 8). Civil aviation in 2023: A vision for the future. *Maspero - Egyptian National Media Authority*. <https://www.maspero.eg/reports-economy/2024/01/08/748299/>
8. Al-Jawari, F. (2018, November 5). Future strategy for human resources management in the aviation sector in Iraq. *Kitabat*. [Link unavailable]
9. International Civil Aviation Organization (ICAO). (2025). *Aviation 2026–2028: Investing in safe skies, sustainable future, active and emerging aviation safety risk programme*. https://www.icao.int/publications/Documents/1/Annex-SummaryFundingRequest_Aviation2026-2028_InvestinginGlobalConnectivityandGrowth.pdf
10. Zhang, F., & Graham, D. J. (2020). Air transport and economic growth: A review of the impact mechanism and causal relationships. *Transport Reviews*, 40(4), 506–528. <https://doi.org/10.1080/01441647.2020.1738587>
11. Amer. (2025, May 20). Qatar Economic Forum reveals the role of partnerships in supporting global aviation. *Al Jazeera*. <https://www.aljazeera.net/ebusiness/2025/5/20/-مندی-قطر-الاقتصادي-يناقش-دور>
12. Zaki, F. (2024, January 8). Civil aviation in 2023: A vision for achieving a sustainable economic future. *Maspero - Egyptian National Media Authority*. <https://www.maspero.eg/reports-economy/2024/01/08/748299/>
13. Prakash, R. (2024, January 8). *The role of aviation in economic development* (Master's thesis, Dublin Business School). DBS eSource. <https://esource.dbs.ie/server/api/core/bitstreams/dd6d6f67-ae98-4b2c-9fba-1d562f2d7ad7/content>
14. Mustafa, K., Saadet, Z., Ali, Y., & Davut, K. (2012, May 31–June 1). Sustainable development in aviation industry and the case of Turkish Airlines. In *3rd International Symposium on Sustainable Development* (pp. 157–167). Sarajevo. <https://core.ac.uk/download/pdf/153447925.pdf>
15. Ministry of Planning–Iraq. (2019, May 22). *First voluntary review on the Sustainable Development Goals: Iraq, sustainable development 2030*. United Nations. https://sustainabledevelopment.un.org/content/documents/23321Iraq_VNR_2019_final_AR_HS.pdf
16. Bonser, M. P. (2019). Global aviation system: Towards sustainable development. *International Journal of Aviation, Aeronautics, and Aerospace*, 6(3), 1–12. <https://doi.org/10.15394/ijaaa.2019.1360>
17. United Nations. (n.d.). *Sustainable development goals*. <https://www.un.org/sustainabledevelopment/ar/sustainable-development-goals/>
18. [Same as #18 – no need to repeat in APA unless specifically cited differently.]
19. Hari, T. K., Yaakob, Z., & Binitha, N. N. (2015). Aviation biofuel from renewable resources: Routes, opportunities and challenges. *Renewable and Sustainable Energy Reviews*, 42, 1234–1244. <https://doi.org/10.1016/j.rser.2014.10.095>
20. United Nations & ICAO. (2025). ICAO launches 1.2MW solar-at-gate pilot project in Cameroon to reduce aircraft CO₂ emissions during ground operations. <https://www.icao.int/Newsroom/Pages/AR/ICAO-launches-1.2MW-solar-at-gate-pilot-project-in-Cameroon-to-reduce-aircraft-CO2-emissions-during-ground-operations.aspx>
21. Rudaw Digital. (2024, September 16). *Kurdsat news coverage*. https://www.rudawarabia.net/arabic/middleeast/iraq/1609202413?utm_source=
22. Iraqi Media Network & Kurdsat News. (2024). *Untitled news report*. https://964media.com/500779/?utm_source
23. 964media. (2025, January 19). *News article*. <https://964media.com/500779>