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Creating Flight Safety Risk Analysis System: Samsun Çarşamba Airport Example

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ABSTRACT

This study examines the risk analysis and results carried out around Samsun Çarşamba Airport through the Flight Safety Risk Analysis System (FSRAS), which was developed to increase aviation safety and minimize risks. It focuses on the effects of land management and zoning legislation on flight safety associated with development around the airport. In the study, possible threats to flight safety due to environmental factors and human activities were determined and risky areas were analysed. With the software developed using the Python programming language, dynamic spatial queries were made via Google Maps and Google Places APIs, and the results were visualized on the QGIS platform. The analysis revealed the existence of structures that could threaten flight safety, such as a waste separation facility within the 13-kilometer risky area, fuel stations in the 15-kilometer risky area, places of worship and schools in the 3-kilometer risky area. In this context, it is recommended to minimize risky construction around the airport and to implement land management policies in accordance with international standards.

Keywords: Flight safety, risk analysis, transport safety, land management, disaster management.

1. INTRODUCTION

The aviation industry is growing day by day with the influence of globalization and a significant increase is observed in the number of flights. Since the early 2020s, there has been a huge increase in passenger and cargo transportation around the world. Especially the Asia-Pacific and Middle East regions are among the regions that contribute the most to the growth of the aviation industry (Boeing, 2021; Gemici and Yılmaz, 2019). According to International Air Transport Association (IATA) data, while the annual number of passengers worldwide

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was 2.5 billion in 2010, this number exceeded 4.5 billion in 2022 (IATA, 2022). However, this growth has also increased the pressure on airports and created new challenges in issues such as aviation security and infrastructure management.

Although the development of technology has increased efficiency in aircraft designs and aviation operations, the increasing number of flights challenges the capacity of the airspace (Pai, 2010). Traffic congestion and delays stand out as important problems, especially at airports in large metropolises. In addition, although the aviation industry experienced a serious pause during the COVID-19 pandemic, the growth trend in the sector continued rapidly during the post-pandemic recovery period (Gössling et al., 2021; Sun et al., 2023). These mentioned issues can be clearly seen in Figure 1 (Okumuş & Asil, 2007; Hatipoğlu & Işık, 2015; Erol & Kanbur, 2017; Blackwell et al., 2013 ;Warnock-Smith et al., 2021).

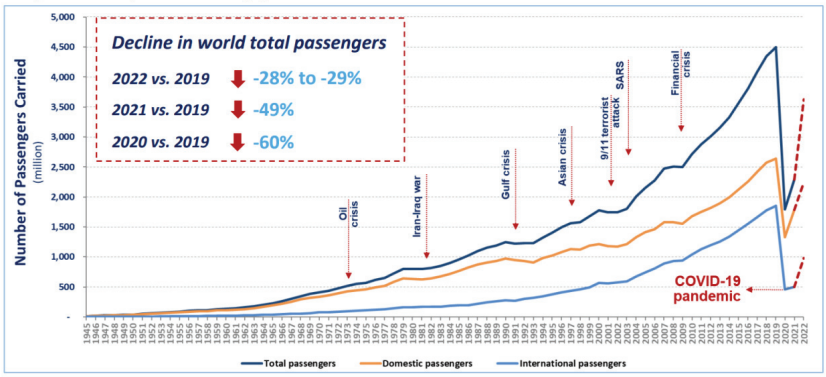

Figure 1 - Number of passengers carried

Research shows that airports around the world have capacity utilization rates above 85%, which will allow new airport projects and expansion of existing airports to accommodate more flights in the future (Graham & Guyer, 2020). Aviation investments, especially in developing countries, play a critical role in ensuring the sustainability of this growth (Forsyth et al., 2019). However, increasing flight trips bring not only economic growth but also environmental and social factors to the agenda (Evans and Schäfer, 2013). While aircraft emissions continue to pose a major threat to environmental sustainability, the increase in flight traffic further deepens this threat (Schumann, 2002; Tsague, L., and Tatietsé, 2007)

For the part so far, it can be said that the growth in the aviation sector causes the number of flights to increase, and this causes the sector to pose new challenges on issues such as infrastructure, security and environmental sustainability (Evans and Schäfer, 2013). Research reveals that the aviation industry requires more investment and innovation in order to manage this growth sustainably (Karaman et al., 2018; Afonso et al., 2023).

Land management, zoning legislation and management of areas around airports have a critical role in minimizing risks in the aviation industry. Protecting airports against risks arising from environmental factors and human activities is a necessity for aviation security (Dobryak et al., 2019). Research shows that construction and land use around airports can

pose significant threats to flight safety (Khalafallah and El Rayes, 2006; Andringa et al., 2022). In this context, effective land management and zoning planning should include not only environmental regulations but also risks directly related to flight safety.

Controlling the construction around airports is of great importance on air traffic. Construction and uncontrolled increase in human activities can create serious risks during the landing and take-off phases of aircrafts (Bienz, 2004; de Oliviera, 2024). The International Civil Aviation Organization (ICAO) has developed a number of standards on this subject and emphasizes that certain criteria must be met around airports (ICAO, 2020). For this reason, local governments need to harmonize their zoning policies with international standards and strictly monitor the construction around the airports. Effective implementation of land management and zoning legislation plays a critical role in reducing risks in and around airports. Studies reveal that improper construction around airports can increase various security risks, such as bird collisions, the presence of facilities where people can gather together, and the presence of flammable explosive storage structures (Allan, 2000; Dolbeer, 2006; Wright & Dolbeer, 2009; Li and Liang, 2018; Di Mascio et al,. 2024, Uzun, 2024.). Many academic studies have been conducted around the world on this subject, symposiums and congresses have been organized and solutions to this issue have been sought (Cleary & Dolbeer, 2005; Linnel, et al., 1996; Sodhi, 2002; Allan and Orosz, 2001; Hardt et al., 2009; Vasilis et al., 2005; Keirn et al., 2010; Nikolajeff, 2013; Mendoca et al., 2017).

Especially in large metropolises, the densely structured areas around airports create significant problems in terms of flight safety. Airports with large traffic are negatively affected by construction activities. For example, increasing commercial construction around New York John F. Kennedy Airport has negatively affected landing and takeoff traffic (Zummo and Murrell, 2011).

Minimizing risks is of critical importance. However, ensuring sustainable urbanization is also an important issue. In this context, a balance must be achieved between environmental sustainability and flight safety in the aviation industry. “Green corridors” policies implemented in countries such as Germany and the Netherlands envisage limiting construction around airports and protecting natural areas. Such policies both support environmental sustainability and have a positive impact on aviation safety. For example, protecting green areas around Frankfurt Airport has increased flight safety while also providing environmental benefits (Ferrulli, 2016).

In addition, research data shows that the majority of plane crashes occur in and around the airport (FSF, 2022; Huang, 2020; Göv & Kahraman, 2022). This situation can be clearly seen in Figure 2 (NTSB, 2019). For this reason, managing airports and surrounding areas is of critical importance.

In Türkiye, although construction and land use in and around airports are regulated by law, there are some difficulties in practice and there are no deterrent rules (Uzun and Sesli, 2020). Local governments actions against zoning plans and lack of supervision can have negative effects on flight safety (Çakirgöz, 2017). This situation creates the need for tighter control and more effective cooperation in order to minimize the risks related to construction around airports in Türkiye.

Effective implementation of land management is of strategic importance for aviation safety. In this context, it is a great necessity to adopt international standards and ensure that local

governments comply with these standards. In order to ensure flight safety, zoning legislation and land management policies need to be addressed with a holistic approach. Especially in developing countries, reorganizing zoning policies in accordance with international aviation safety standards will both protect human life and reduce operational costs in the aviation industry (Umilia, 2014; Stolzer et al., 2023).

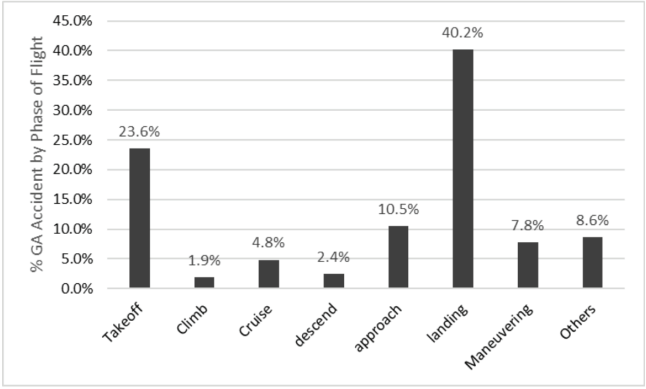

Figure 2 - Aircraft accidents by position

In the light of aforementioned issues and concepts, Flight Safety Risk Analysis System (FSRAS), an original system, has been developed in this study to ensure flight safety through land management, risk analysis and map analysis results. The criteria employed in this proposed sytem have been defined based on on the international criteria updated for a more effective land management. The criteri constitute three zones such that: 1) Within a circular area with a radius of 13 km from the airport's main center, there should be no waste separation, garbage collection, recycling facilities, or similar facilities that could attract flying creatures. 2) There should be no storage facilities or fuel stations containing any kind of flammable or explosive substances in the circular area within a 15 km radius from the airport's main center. 3) There should be no facilities such as mosques, churches, schools, wedding halls where people can gather in the circular area within a 3 km radius from the airport's main center. Existence of violations in these risky areas were analysed with a software coded in Python programming language, and the analysis results were mapped with Quantum GIS geographic information system software.

2. METHODS

2.1. Study Area

Samsun Çarşamba Airport is an important civil airport located in the Black Sea Region of Türkiye. The airport is located at 41.2560° north latitude and 36.5677° east longitude (General Directorate of State Airports Authority [DHMI], 2023). Opened in 1998, Samsun Çarşamba Airport serves both domestic and international flights. The number of daily flights varies between 20-30, and there are regular flights, especially to and from Istanbul and

Ankara (Turkish Airlines [THY], 2023). According to 2022 data, the airport served approximately 1 million passengers annually (DHMI, 2023). The airport is located in a strategic location due to the geographical structure of the Black Sea and makes significant contributions to the commercial and touristic activities of the region (Civil Aviation Authority, 2023) (Figure 3).

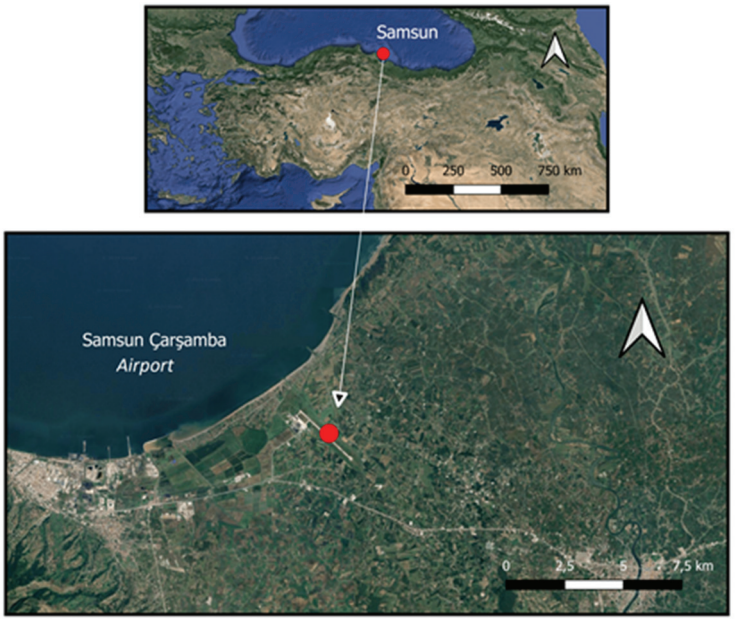

Figure 3 - Location of Samsun Çarşamba Airport

2.2. Quantum GIS (QGIS) Software

QGIS (Quantum GIS) is an open source geographic information system (GIS) software. It offers users a wide range of GIS functions such as map creation, data analysis, spatial queries and visualization. QGIS is a powerful platform that allows users to perform various analysis on geographic data and visualize this data effectively. In this study, it was used to visualize and map the analysis results.

2.3. Buffer Analysis

Buffer analysis is a frequently used method in geographic information systems (GIS) and spatial analysis. This method creates a "buffer" zone around a specific geographic object, allowing objects or features within that defined area to be examined.

2.4. Pycharm Software

PyCharm is a popular integrated development environment (IDE) developed for the Python programming language.

2.5. Flight Safety Risk Analysis System Written Development (FSRAS)

In order to detect violations in risky areas, a software capable of performing spatial analysis has been developed using the Python programming language. In this software, Google Maps API, Google Geocoding API and Google Places API applications, which can make dynamic spatial queries to perform spatial analysis, have been enabled and an API Key has been obtained from Google. The API Key in question has been integrated into the software developed to perform dynamic spatial analysis. When performing spatial analysis, the software uses a geographical coordinate system that uses latitude and longitude data to appeal to all disciplines.

3. RESULTS

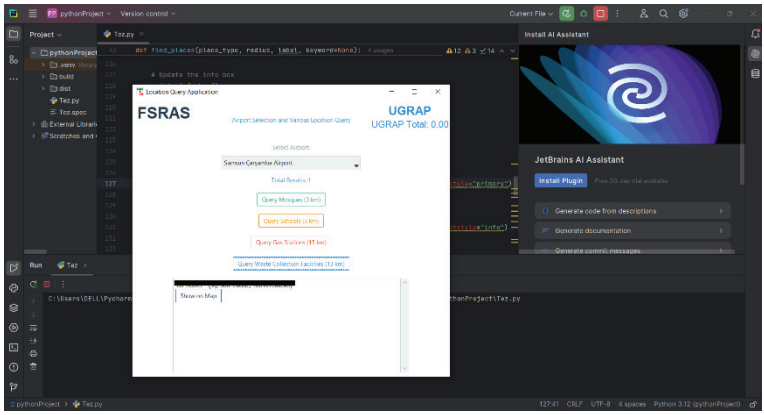

Figure 4 - FSRAS analysis results

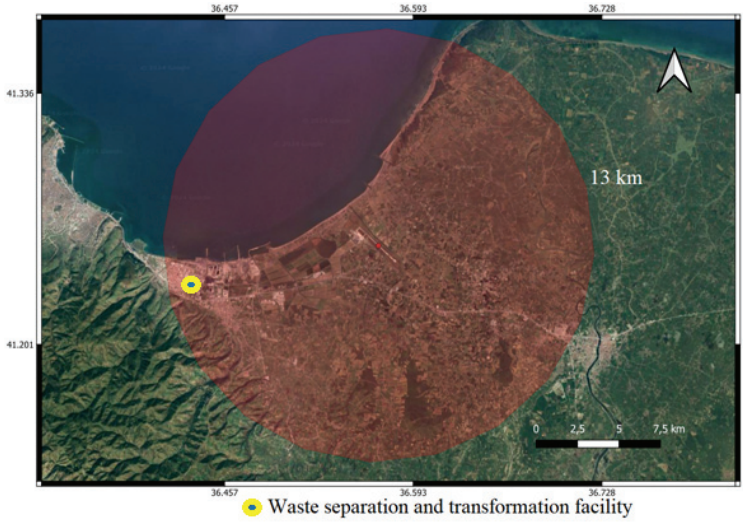

Figure 5 - Location of waste separation and transformation facility

It was seen that the waste separation and transformation facility, which is a private institution and located within a 13 kilometer risky area, was detected in the analysis made by FSRAS. The facility in question is 11.66 kilometers away from the airport center. Again, 7 fuel stations, 4 mosques/masjids and 4 schools that may pose a risk to flight safety were identified (Figure 4-7).

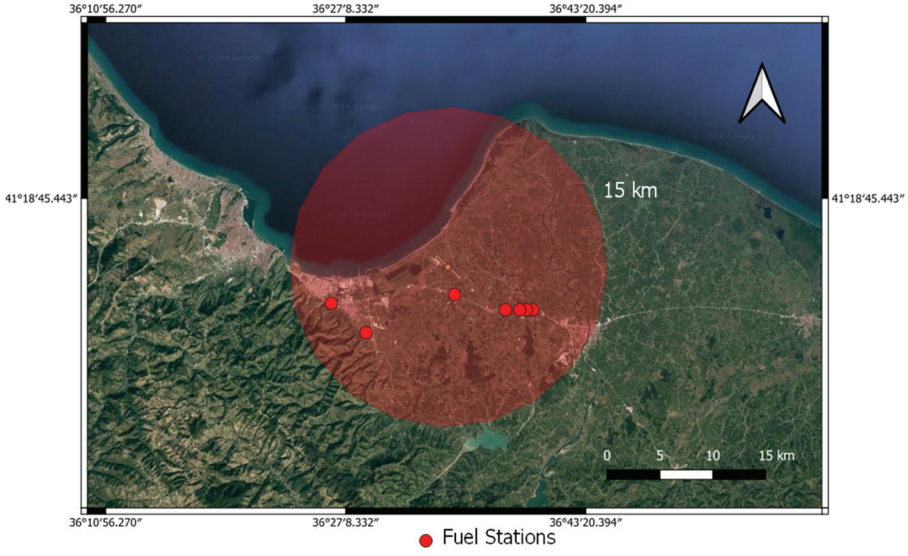

Figure 6 - Locations of fuel stations

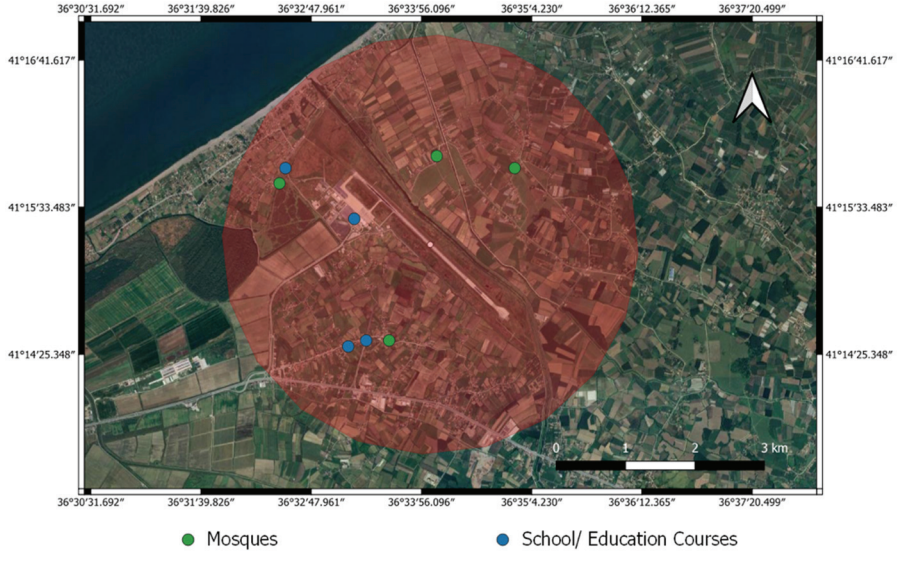

Figure 7 - Locations of mosques and education centers

4. DISCUSSION

In this study, the potential effects of existing construction around the airport on flight safety of Samsun Çarşamba Airport were analysed using the Flight Safety Risk Analysis System (FSRAS) developed. The study results revealed that some structures around the airport may pose a risk to flight safety. For example, the waste separation and recycling facility located within the 13-kilometer risky area threatens flight safety due to its potential to attract birds. Similarly, fuel stations located within a 15-kilometer area carry the risk of storing flammable and explosive materials, creating the danger of fire and explosion. In addition, public gathering areas such as mosques and schools, located within the 3-kilometer risk area, pose an additional risk due to the density on the flight paths.

In this context, it is understood that the construction around the airport should be managed not only by legal regulations but also by an effective control mechanism. Although there are laws regulating the construction around the airport in Türkiye, difficulties in implementation and lack of control negatively affect flight safety. Therefore, it is of great importance for local governments to act in accordance with international standards and make decisions based on risk analysis.

FSRAS used in the study provides an effective method to detect structures that pose a risk to flight safety by analysing environmental risk factors. The system is a dynamic query tool developed using Google Maps and Google Places APIs and visualizes the analysis results on the QGIS platform. Applying this system to other airports and evaluating the data obtained through comparative analysis may enable flight safety policies to be addressed more comprehensively.

5. CONCLUSION

As a result, in this study, a method, Flight Safety Risk Analysis System (FSRAS), which has been developed to detect risks around airports and minimize these risks used for the assessment of risks of Samsun Çarşamba Airport. Analyses have shown that waste separation and transformation facilities, fuel stations, places of worship and educational institutions around the airport may pose serious risks to flight safety. Especially structures that attract birds, such as waste facilities, pose great threats to the safety of aircraft landing and takeoff, and it is not recommended to locate such facilities close to the airport.

In the light of the data determined as a result of the analysis, it was seen that the waste separation facility located in the risky area 13 kilometers around the Çarşamba airport poses a risk in terms of flight safety. Similarly, since fuel stations and areas where other flammable materials are stored carry the risk of explosion and fire, these facilities should not be located close to airports. In addition, areas where people gather densely, such as places of worship and schools, pose an additional risk due to the density on the flight route, and it is important to keep such structures at a certain distance.

Research data reveal that construction around airports should be managed not only by legal regulations but also by an effective control mechanism. Although there are legal regulations on this subject in Türkiye, weaknesses in implementation and lack of control negatively affect flight safety. Therefore, it is of great importance for local governments to act in accordance with international standards and make decisions based on risk analyses. In this context, local

governments need to adopt stricter rules in zoning plans and land management practices. Protecting green areas and limiting construction around the airport is a critical step in terms of both environmental sustainability and flight safety. "Green corridor" policies implemented in countries such as Germany and the Netherlands minimize the risks to flight safety by limiting construction around the airport.

Recommendations include further development of existing risk analysis systems and their implementation on a regional basis. Although FSRAS is an important step in this context, evaluating the data obtained by applying the system at other airports with comparative analysis will enable flight safety policies to be addressed more comprehensively. In addition, new legal regulations and control mechanisms to be developed in accordance with international standards can significantly increase airport security in Türkiye.

In addition to all these suggestions, a legislative proposal has been produced in order to provide legal support for the solution:

Draft Law on Land Management and Construction around the Airport

Article 1 - Purpose and Scope

The purpose of this law is to create a framework in line with international standards to increase flight safety and ensure environmental sustainability by regulating construction and land use around airports. The law covers regulations on construction, land use and activities within a 15-kilometer area around airports.

Article 2 - Definitions

Risky Area: Areas with a radius of 3, 13 and 15 kilometers from the airport center.

Hazardous Structures: Waste facilities that attract birds, explosive or flammable material storage areas, buildings with dense human communities (school, place of worship, etc.).

Article 3 - Prohibited Activities

It is prohibited to have waste collection, separation or recycling facilities that would attract birds in the risk area with a radius of 13 kilometers.

It is prohibited to build facilities where explosive, flammable and hazardous materials are stored within a 15 kilometer radius.

It is prohibited to establish structures that may cause mass human movement, such as schools, places of worship and wedding halls, within a 3 kilometer radius.

Article 4 - Zoning Regulations

Local governments are obliged to revise development plans in accordance with the rules specified in this law. New building permits will be evaluated for compliance with international aviation safety standards.

Article 5 - Inspection and Monitoring

All construction and activities around airports will be checked regularly.

Relevant institutions are authorized to remove or move structures and facilities that threaten flight safety.

Article 6 - Criminal Sanctions

Sanctions such as fines, license cancellation and demolition are applied for activities contrary to the provisions of this law. Additional legal responsibilities are imposed on individuals or institutions that endanger flight safety.

Article 7 - Compliance with International Standards

The standards set by the International Civil Aviation Organization (ICAO) will be taken as basis in the implementation and updating of this law.

Article 8 - Environmental Sustainability

"Green corridor" policies will be implemented around airports.

Environmental impact assessment report is mandatory for new building permits.

Article 9 - Execution

The provisions of this law are enforced by the relevant ministry.

As a result, effective control of the construction around the airport is of vital importance for flight safety. This study, through the example of Samsun Çarşamba Airport, has revealed important findings on how these risks can be analyzed and managed and has provided guidance for future applications.

Data availability

Data will be made available on request.

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