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SUSTAINABLE AVIATION: GIS FOR AIRPORT

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Abstract

Limited natural resources are decreasing day by day. In order for these resources to be used by future generations, the concept of sustainability, which aims to reduce the negative effects of human activities and the effective use of resources, should be implemented. Sustainability practices are essential in the aviation, which is an indispensable sector. In this study, what are the environmental targets within the scope of sustainable aviation practices, and the contributions of Geographical Information Systems (GIS) as an information technology in the process of achieving these targets are discussed. The literature review was conducted and the applications that contributed to sustainability were exemplified by using the GIS tool in the aeronautical organizations and especially in airports. The possible contributions of GIS to sustainable aviation are expressed.

Keywords: Aviation Management, Sustainable Environmental Management, Geographical Information Systems .

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1. INTRODUCTION

Around 7.6 billion people and millions of lives share the same environment around the world. In order to ensure the prosperity of all living beings on the earth, we need to manage effectively the whole area of the environment we are in. The Brundtland Report on Environment and Development in 1987, the Rio Summit which took place in 1992, are the main activities that have gained momentum for sustainable environmental management movements. Within the context of sustainable development approach to managing human activities in harmony with nature, natural, economic and social elements for sustainable environmental management can be defined together as closely as possible in order to minimize the pressure of human activities on the environment and to prevent or mitigate potential future harmful effects should be addressed.

Civil aviation is one of the fastest growing global industries. Impacts of aviation can be either negative or positive. In its present form, aviation cannot be considered sustainable in the very long term. As aviation relies on limited natural resources, achieving sustainable development is not easy but action is needed for sustainable aviation.

Geographical information sciences – Geographical Information Systems (GIS) are effective tools of collecting, storing, analyzing and interpreting data of various kinds. In this study, we will focus on what GIS applications are used in the problem solving process of the airports and what are the contributions of these applications to the airports in the context of sustainable aviation management.

1.1. Geographical information systems

GIS is more than an information system, GIS is the way of thinking about everyday data in a spatial context. GIS can be a great planning and decision making tool for different kinds of disciplines. Various disciplines use GIS. For-instance, environmental-earth sciences, many economic and census related studies use GIS. It helps different kinds of disciplines-companies to incorporate geographic data into their working process, so that they can easily plan, optimize, maintain, and check other activities. Figure 1 illustrates the examples of different kinds of GIS applications and uses.

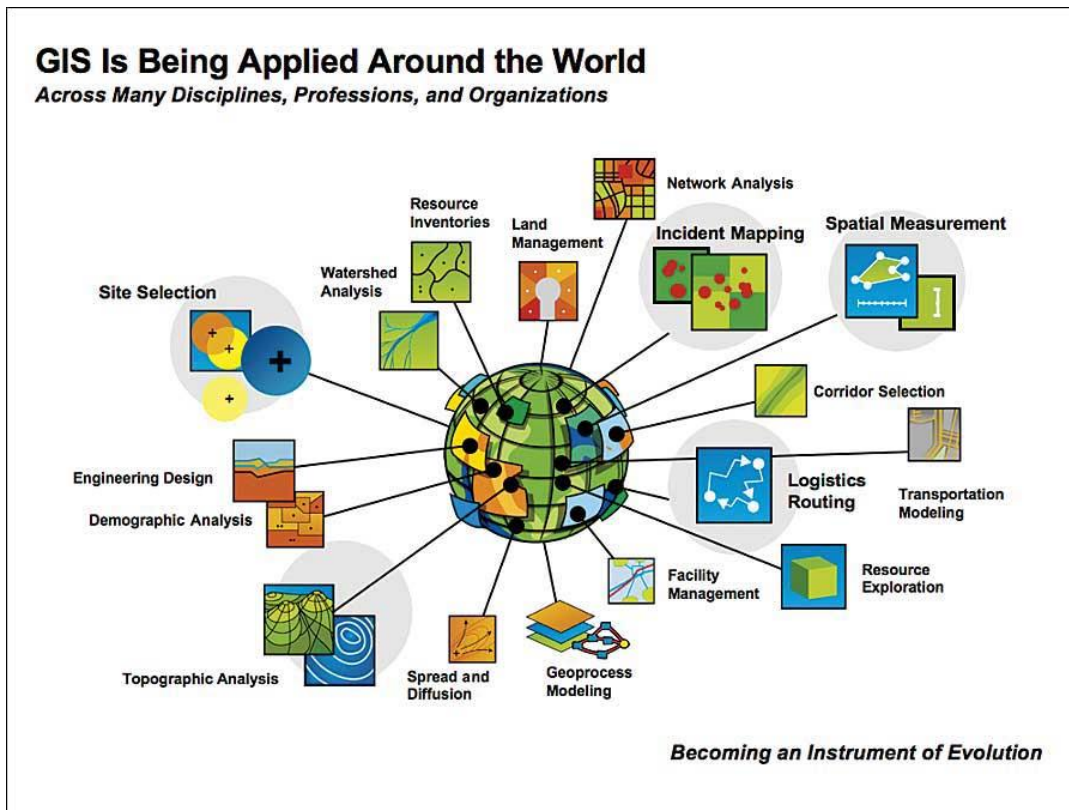


Figure 1: Examples of different kinds of GIS applications and uses
Source: ESRI, 2007

1.1.1 GIS for aeronautical organizations

Aeronautical organizations need to create and maintain digital aeronautical datasets and produce high-quality, database-driven charts that meet their unique specifications. GIS can help these agencies maintain, control, and disseminate data that meets their requirements. With GIS, aeronautical organizations can (ESRI, 2013):

- Create, visualize, analyze, and disseminate critical data from Aeronautical Information Systems (AIS).
- Automatically update charts through the AIS to reduce data latency, redundancy, and errors.
- Produce a wide range of charting products, including International Civil Aviation Organization (ICAO)-compliant charts, from a central database.
- Share data using the Aeronautical Information Exchange Model (AIXM).

- Efficiently generate aeronautical charts for route planning, in-flight navigation, and takeoff and landing.

Many aviation organisations use GIS. For example Pegasus Airlines uses GIS for data management, editing, and validation. They can reduce chart production time for significant time and cost savings. By using GIS, airline inputs changes to its geodatabase and updates each impacted chart automatically. They also use chart templates for new chart production. These updated digital charts are available in each pilot's electronic flight bag (EFB) tablet, and it supports the airline's move to a paperless cockpit (ESRI, 2012).

1.1.2 GIS for airport

Regardless of their size, airports are complex facilities that play a critical role in regional and national transportation. Airport managers must plan and maintain their facilities for peak performance and identify potential points of failure well before a critical failure can occur. Airport managers can use GIS technology to support their efforts in planning, operations, maintenance, and security by adding spatial information and modeling process. Ultimately, GIS helps airports visualize data so they can better understand the relationships between data points and their locations. This results allows to user that, leading to better decision-making and more effective use of available staff and resources (Coffman Associates, 2016).

Facilities Management, Capital Planning, Property/Lease Management , Land Acquisition, Security and Risk Assessment, Flight Path Management, Airport Layout Planning, Capacity Planning, Pavement Management, Parking Management, Courtesy Vehicle Management ,Utility Maintenance, Lighting Management, Noise Monitoring and Modeling and Environmental Assessment processes are examples of airport management processes which can done by GIS(ESRI,2013).

1.2 Sustainable aviation; environmental issues

In late 1980's, early 1990's a variety of research programmes identified a number of emissions and effects from aviation (Lee et al., 2009). The concept of sustainable aviation emerged in the late 1990's with the The Intergovernmental Panel on Climate Change (IPCC) Special Report on the climate change impacts of aviation in 1999 (IPCC, 1999). The term 'sustainable aviation' emerged in reports such as the work of Sledsens (1998) and INFRAS (2000) (Walker and Cook, 2009).

1.2.1 Impacts of aviation

There are lots of impacts of aviation. Impacts of aviation can be either negative or positive. The environmental impacts of contemporary aviation are significant. One of the

first impacts of aviation is global scale impacts. The major environmental impact of aviation is global climate change. According to IPCC 5th assessment report and The International Civil Aviation Organization (ICAO) Environmental Report 2016, distribution of emissions of greenhouse gases by industry sector worldwide as of 2015, Emissions from transportation accounted for 13 percent of greenhouse gases. Total CO₂ emissions from aviation account for approximately 2% of total global CO₂ equivalent emissions. And international aviation accounts for about 13% of total global CO₂ emission (ICAO, 2016).

More locally, aircraft and airport operations caused noise pollution from take-off and landings, engine testing, surface transport and constructions, so that noise pollution is one of the most serious environmental problems of aviation. Other aviation related environmental issues include contaminated land, ground and surface water at airports arising from jet fuels, aircraft de-icing operations, waste generation, threatening the wildlife and farmland (Upham et al, 2003).

Besides the environmental impacts, aviation industry have social and economical impacts. Aviation industry causes affordable access to destinations across the globe, creating job, facilitating tourism and trade and influences tax revenue (ICAO, 2017).

However, it is obvious that, the social, economic and environmental dimensions created by airports directly influence urban, regional and national sustainable growth. Within this context, either negative or positive impacts created by aviation related processes should be predicted and managed by decision makers.

1.2.2. Sustainable aviation goals

The International Civil Aviation Organization (ICAO)'s environmental work contributes to 10 out of the 17 United Nations Sustainable Development Goals. These sub topics are good health, quality education, gender equality, renewable energy, innovation and infrastructure, reduced inequality, responsible consumption, climate action, life on land, partnership for goals, environmental efficiency and mitigation are main goals of sustainable aviation. This study mainly focuses on environmental goals. The International Civil Aviation Organization (ICAO) adopted three major environmental goals, to (ICAO, 2016):

- a. limit or reduce the number of people affected by significant aircraft noise;
- b. limit or reduce the impact of aviation emissions on local air quality; and
- c. limit or reduce the impact of aviation greenhouse gas emissions on the global climate.

1.3. Contributions of GIS for sustainable aviation

GIS provides avoiding irreversible adverse effects of human activities on earth systems. Adverse affects can be obtained before aroused, by using GIS based modeling techniques. For instance we can solve the noise problem. Choosing quieter aircraft may reduce ambient air noise but technological improvements could be more expensive than some specific site based solutions. GIS helps to develop site specific solutions. Potential noises can be prevented by using results of simulating noise pollution. For example noise problem can be solved with land use management. Sadr (2017) predict IKIA airport noise by using GIS. Also, Buitenschot Park Project is a good example of reducing noise problem by managing land use (http-1, 2016). These management processes can be done by GIS based models.

The spatial characteristics analysis of aviation accidents can identify the hot spots where aviation accidents occur frequently and analyze the spatial distribution characteristics of existing aviation accidents. It has important for reducing accidents. Within a GIS, based airport wildlife management program strives to reduce the risk of bird strikes. In Greece, Siopis et al. (2015), show the importance of site selection and land use management for reducing risks. The other example project is Aalborg Airport. Bird strikes have been reduced by 50% in Aalborg Airport by using Copernicus Sentinel satellites and spatial analysis techniques (http-2, 2018). Li and Liang (2018), identified the hot spots where aviation accidents occurred in Florida. Authors used the kernel density function to analyze the hot spots of traffic accidents and analyzed the spatial autocorrelation characteristics of aviation accidents and to determine whether aviation accidents have spatial aggregation trends. On this basis, the severity index of existing aviation accidents has been calculated to study which airports have high potential aviation accident risks in the past 15 years.

Air quality management of airports can be done by GIS techniques. GIS is able to take into account the whole range of relevant emission sources: aircraft traffic, auxiliary power units, ground support equipment, road traffic, industrial, commercial, domestic and other less well-defined sources. In 2002 London Heathrow airport's air quality management done by GIS based model ADMS-Airport which is developed by Cambridge Environmental Research Consultants (CERC)(CERC, 2002). By using this model, air quality current situation and future scenarios can be viewed and by using this model output adding capacity processes can be managed. Figure 2 illustrates example analysis result from ADMS which is shows the modelled NO₂ concentrations around Heathrow.

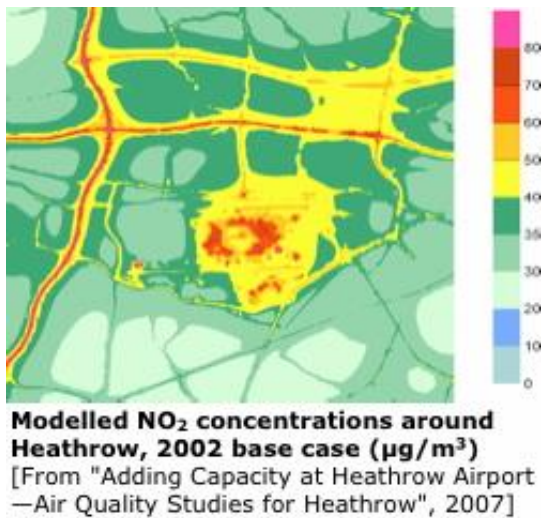


Figure 2: ADMS-Airport

Source: CERC, 2002

In addition to the environmental impacts, by using GIS we can answer these questions,

- Where is the best suitable area for airport?
- How many people affected by impacts of airport?
- When new airport opening, which sectors affected negatively or how many people can find a job?
- Where can we find the cheapest raw material and which way has the less carbon footprint, etc.?

In summary, in line with the goals of sustainable aviation and airport, benefits of GIS for sustainable aviation (ESRI, 2013);

- Reduced Emissions
- Provide the ability to track assets, conduct real-time analysis, and produce what-if scenarios on live or recorded aeronautical information feeds.
- Promote Sustainable Growth
- Sharing the use of the technology ensures that the correct data is used throughout the organization and that resources are shared for more viable growth.

2. CONCLUSION

Using GIS in aviation, especially in airports, allows the airports to collaborate more effectively and efficiently on airport planning, design, operations, and maintenance decisions. Also, GIS provides avoiding irreversible adverse effects of aviation on earth

systems. By using GIS-based modeling techniques, the harmful effects of aviation can be prevented before its arousing. Some pollution prevention activities (for instance noise pollution, protecting surface and groundwater systems, air quality management), protecting wild life, reducing risks (bird attack etc.) and some improvement of economic and social well-being can be done by GIS.

In addition to the existing practices, in the future coupling with advances in web based applications, enables the airport to access to its data anywhere there is an internet connection. This means that an airport manager can easily answer critical questions. Also, technology integration makes GIS more accessible, as people are able to use alternate devices (such as smartphones and tablets) to run the web-based applications. It will reduce costs of traditional GIS systems. Over the long-term, with the improved data management GIS will provide faster, easier access to information. GIS technology will eliminate the need for paper-based management. In conclusion, with digital management of airport information, airports will be both efficient and sustainable (Coffman Associates, 2016). To sum up, the purpose of the present paper is to show that it will be easier to achieve sustainable development goals by using GIS in airports and the many aviation activity.

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