Journal of Air Transport Management 63 (2017) 61–70

Contents lists available at ScienceDirect

Journal of Air Transport Management

journal homepage: www.elsevier.com/locate/jairtraman

Indicators and evaluation model for analyzing environmental protection performance of airports

Ching-Cheng Chao Professor [a, *], Taih-Cherng Lirn Associate Professor [b], Hung-Chun Lin Master [a]

[a] Department of Shipping and Transportation Management, National Kaohsiung Marine University, 142 Hai-Jhuan Road, Nan-Tzu, Kaohsiung 811, Taiwan, ROC

[b] Department of Shipping and Transportation Management, National Taiwan Ocean University, 2 Pei-Ning Road, Keelung 20224, Taiwan, ROC

ARTICLE INFO

Article history:
Received 7 September 2016
Received in revised form
29 March 2017
Accepted 24 May 2017

Keywords:
Fuzzy Delphi method
Environmental protection
Energy conservation
Carbon reduction

ABSTRACT

This study develops an evaluation model for analyzing environmental protection performance of airports. First, indicators for evaluating environmental protection at airports are derived by reviewing related literature and existing environmental management plans using the Fuzzy Delphi method. Then, the weights and value functions of these indicators are obtained through expert questionnaire surveys. Applying the value functions to the environmental data from different airports yields the value of each indicator. Finally, multiplying the values with their corresponding weights sheds light on the performance of individual and overall indicators. Findings of this study offer references for airport management in evaluating airport performance in energy conservation, carbon reduction, and implementation of environmental protection measures, as well as in developing performance improvement schemes according to the state of the airport.

1. Introduction

Faced with the intensifying impacts of environmental change, resource shortages, and greenhouse effects on the global environment, the international community has become increasingly focused on issues of environmental protection, energy conservation, carbon reduction, and sustainable development, all of which are now issues of worldwide concern. Environmental protection and efforts to ameliorate the impact of environmental change have become scientific challenges of our times. Escalating growth in civil aviation can be attributed to an increasingly globalized society, but at the expense of surges in energy consumption and health-threatening pollution. With heightened public environmental awareness, increasing effort is being put into research on issues of aviation-related environmental protection. Research on eco-friendly indicators within the air transport industry focuses mostly on strategic application and aircraft technology improvements for mitigating the negative effects of the industry's operations on the environment (Mayer et al., 2012).

To ensure safety for aircraft takeoff and landing, provide services for passenger entry and exit, and facilitate import and export of goods, airports require enormous amounts of land and building space. Depending on the geographical environment and climate of their respective locations, power, fuel, and water resources consumed by airports vary, as do their negative effects on the environment (Pitt et al., 2003). Major environmental concerns at most airports are noise, local air and soil quality, ground and surface water, recycling and sustainability, as well as habitat and wildlife management (Cherry, 2008). Several international examples (CEIT, 2009) have demonstrated that environmental protection plays a major role in the strategy and development plans of many airports around the world. These examples also offered solutions, including logistics and technology indicators, for improving the energy efficiency of airport facilities, construction of sustainable airport buildings, as well as use of renewable energy sources and low-emission fuels for airside maintenance vehicles. Increased awareness and concern for environmental protection does contribute to greater demand for “green” technology and the development of climate-friendly indicators for airports (CEIT, 2009).

Developing sustainable airports is the future of airport planning

* Corresponding author.
E-mail addresses: chaocc@webmail.nkmu.edu.tw (C.-C. Chao), tedlirn@hotmail.com (T.-C. Lirn), 1001538104@stu.nkmu.edu.tw (H.-C. Lin).

http://dx.doi.org/10.1016/j.jairtraman.2017.05.007
0969-6997/

because airports have an impact on the surrounding environment and residents therein. Therefore, it is important for airports to be socially and environmentally responsible. Nevertheless, current airport evaluation is still geared towards passenger service quality. For example, an Airport Service Quality (ASQ) Program, an initiative by Airports Council International (ACI), assesses and ranks various operations and services at airports around the world and helps improve airport service quality. However, there are now few evaluation indicators established by civil aviation organizations for airport environmental protection and evaluation. To make up for such deficiencies, this study develops an evaluation model for analyzing airport environmental performance. This is donned by selecting applicable environmental rating indicators according to airport characteristics and developing calculation methods for these indicators in order to reduce environmental pollution from airports and achieve energy conservation and carbon reduction. The model can be used by airport management to examine airport performance in energy conservation, carbon reduction, and implementation of environmental measures, and to develop performance improvement schemes according the geographical environment and state of the airport.

The first part of this study includes a review of past research on airport environmental protection including energy conservation and carbon reduction, an introduction to the implementation of environmental measures and the state of energy conservation and carbon reduction at different airports, and a summary of selected applicable indicators for rating airport environmental protection performance. Dimensions and indicators for the evaluation of airport environmental protection performance were selected using the Fuzzy Delphi Method (FDM). Expert opinions on the summarized indicators were solicited in the first round of a questionnaire survey, followed by the second questionnaire, which was intended to obtain the weights of the selected environmental rating indicators using the analytic hierarchy process (AHP) and to examine accordingly the value functions of these indicators. With actual data collected from international airports, including Narita, Incheon, and Kaohsiung, calculations were made to obtain the values of individual indicators for comparing these five airports in terms of their performance on individual and overall indicators, as well as different dimensions. The evaluation model developed in this study can not only analyze environmental protection performance of airports, but can also compare performance among neighboring or competing airports on individual dimensions and indicators.

The rest of this paper is organized as follows. Section 2 reviews studies on environmental management plans at different airports. Section 3 introduces environmental indicators, research methods, and the development of an evaluation model for airport environmental protection performance. Section 4 details the empirical analysis of environmental protection performance among five airports. Section 5 provides conclusions and suggestions.

2. Literature review

Environmental management plans and eco-friendly policies and strategies have been increasingly adopted by airport management. Noise reduction through improved air traffic management techniques, emissions controls for aircraft engines and ground maneuvering vehicles, water recycling and reuse for airfield pavement cleaning, and use of renewable energies and photocatalytic materials are only some of the numerous ways to establish a sustainable airport. Prior research on airport environmental protection focused mainly on two factors: noise pollution (e.g., Brechet and Picard, 2012; Girvin, 2009; Lijesen et al., 2010; Prats et al., 2011) and air pollution (e.g., Anger and Kohler, 2010; Girardet and Spinler, 2013; Kurniawan and Khardi, 2011). Studies emphasizing other factors included Upham (2001), who provided a comparison of sustainability theory between UK and European airports' policies and practices. With regard to the reviewed airports as a whole, there is no evidence of a reduction in total environmental impact or commitment to general consumption or waste limits, but rather of extensive mitigation aimed at regulatory compliance with selected local environmental quality standards, environmental efficiency, and cost reductions.

The operations and long-term planning of the combined heat, power, and cooling (CHPC) plant supplying power to the Milan Malpensa Airport were investigated using profit-oriented linear optimization and a series of plant running simulations. An analysis of the relationship between energy and net cash flow indicated that a purely profit-oriented management model could significantly increase annual energy savings (Cardona et al., 2006). Sölveling et al. (2011) developed an integrated approach that models this complex relationship, and provided insights into the value of environmental optimization for runway scheduling. They reported that while significant savings in environmental costs could be achieved through environmentally optimal scheduling, these savings were not very different from those obtained through optimal fuel scheduling. Giustozzi et al. (2012) focused instead on construction techniques and the development of innovative materials that help achieve environmental sustainability on airfield pavements. Their environmental analysis of a major Italian airport showed that almost 35% of emissions could be avoided if recycling was practiced.

The resolution on climate change at ACI's annual general assembly in 2007 encouraged all airports to make firm commitments to environmental goals within their own control, including implementing strategies to reduce carbon emissions with the ultimate target of becoming carbon neutral. The main fields of action for the reduction of greenhouse gas emissions include reducing energy consumption in buildings, producing zero- or low-emission energy as an alternative fuel for Ground Support Equipment (GSE), increasing fuel economy in aircraft including Auxiliary Power Units (APUs), promoting zero- or low-emission vehicles, reducing the number of vehicles allowed to access airports, adopting emissions trading, and purchasing carbon offsets (Cherry, 2008).

An Environmental Management System (EMS) is an organizational structure that ensures an organization proactively and systematically manages its operations that have potential environmental effects so that it meets its regulatory compliance obligations. EMSs have been widely adopted internationally by industry and government, and have been effective in improving organizational regulatory compliance and environmental performance, as well as supporting mitigation monitoring. EMSs are increasingly being used in the aviation industry to manage environmental issues. Some airports refer to the international standard 'ISO 14001: 2004 Environmental Management System' for requirements and guidance on structuring and defining their EMSs.

Graham (2005) provided an overview of the current attitudes and practical experience with airport benchmarking. The partial performance measures were used for economic, operational and environmental aspects. Environmental performance indicators commonly measure noise and emission pollution, water and energy use, waste treatment and recycling and use of public transport (Graham, 2005, 2013). Upham and Mills (2005) proposed and assessed a core set of environmental and operational sustainability indicators for airport benchmarking by researching a decision support tool designed to support environmental and operational sustainability for airports.