Evaluation of sustainability components at passenger airports by extension of interval type-2 Fuzzy DANP technique

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Abstract

Sustainability components have received increasing attention at passenger airports to improve service quality and preserve the environment while reducing costs. Although sustainability components can bring a lot of advantages, they are not familiar for many airports' managers especially in developing countries like Iran. That is why after performing interval type-2 fuzzy Delphi technique; mutual relationships of the components are investigated by application of interval type-2 fuzzy DEMATEL technique. It is remarkable that such an integrated approach toward determining components has led to a set of components that are concise and also sufficiently comprehensive. Meanwhile, interval type-2 fuzzy DEMATEL technique is helpful in determining which components have affections on others. Such knowledge about relationships among components makes it possible to lead them in the right direction by directing influencing components properly. Finally, the weights of the components are determined by interval type-2 fuzzy extension of DANP technique in order to specify which component has the greatest priority in making passenger airports more sustainable. This extended technique considers the mutual relationships of components and can keep uncertainty though the whole steps of determining their weights. Results show that policy making (C1) and social responsibility (C10) have the highest weights and the greatest effects on other components of the system. So, airport managers should consider suitable visions, strategies and defined milestones for every aspect of sustainability while policy making and pay special attention to the airport social responsibility through this way.

Keywords

DANP technique, Delphi technique, DEMATEL technique, Interval type-2 fuzzy sets, Passenger airports administration, Sustainable airport

1. Introduction

Economic, social and environmental components have simultaneously gained attention under the name of sustainable development [1]. Nowadays governments and different international agencies ask organizations to pay attention to environmental components in

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order to make their procedures consistent with green principles [2]. This may be one of the reasons there is increasing concentrations on the concept of sustainability in producing goods and services. Acting in line with sustainability components provides economic growth and also helps to preserve the environment. In addition, it can improve corporate reputation by paying attention to the social responsibility concept [3].

Meanwhile it is noteworthy that the transportation industry can benefit a lot from sustainability. It is clear that life in today's world is very dependent on transportation. Aviation connects the world and can of course positively or adversely affect the environment. It not only connects people but it can connect economies and is crucial for increasing job opportunities and GDP growth [4]. It can also cultivate local culture and it can cause different kinds of environmental pollution to increase [5].

It should be mentioned that airports play a great role in making air transportation possible. Airports are more than just a place containing planes. They are vital national resources and are essential connections for social and economic interaction. They can increase the rate of local employment. So the whole society can benefit if airports do well in presenting high quality services [6,7].

The importance of making airports sustainable is crucial in this respect. Airports need well connected infrastructures not just in physical respects but also in social ones. Although studies are done about sustainability, actual implementation is still not satisfactory. This makes investigations in this domain necessary [8]. Iran airports are not exception too. There are 54 airports in Iran and 9 of them are counted of international ones. Many of them are not profitable and the rate of non-aviation income is far less that the global rate. Another matter is that these airports are encountered with different regional cultures and various atmospheric conditions or different species of animals and plants. This means that the airport may not be comfortable to communicate effectively with local shareholders and may face natural disasters such as hurricanes or have difficulties in not harming species unintentionally. So, it is undoubtable that radical review of the ways linked to increased sustainability of each Iran airport can enhance its economics, social and environmental situation.

This is why there is a need to set sustainability components to measure the progress of sustainability at airports. There are various components being developed by different agencies. Heathrow airport management is one of the first that paid attention to setting a list of components for improving the sustainability of its operations [9]. The Sustainable Aviation Guidance Alliance (SAGA) has set guidance with the 5 main steps of share, learn, search, plan and measure that help airport managers measure progress toward sustainability [10]. The Transportation Research Board (TRB) has developed a rational comprehensive list of components in order to help airports become green. TRB has conducted the Airport Cooperative Research Program (ACRP) which established guidance for identifying and incorporating sustainable components, green technologies and recycling strategies into traditional airport projects [11].

In fact a large number of components have been identified. Therefore the selection of components and determining their importance or priority is not easy especially for airports in developing countries such as Iran that have started progressing toward sustainability so recently compared to developed countries. Fortunately, multi-criteria decision making (MCDM) techniques can be of great help in sustainable transportation components selection or importance determination as a whole [12,13, 14].

So the main objective of this paper is to present criteria to evaluate sustainability components at airports. These components are determined by application of interval type-2 fuzzy Delphi. Based on this objective, Decision Making Trial and Evaluation (DEMATEL) technique is used to determine the mutual relationships of the considered components. DEMATEL is based on experts' opinions. This technique is combined with interval type-2 fuzzy sets in order to make it possible for the experts to deal with existing ambiguity. On the one hand it must be said that membership functions of type-1 fuzzy sets do not take account of uncertainty and on the other hand, excessive arithmetic operations are needed with type-2 fuzzy sets. That is why some fuzzy multi criteria methods have recently be extended by using interval type-2 fuzzy sets which consider uncertainty in membership functions by paying attention to interval numbers [15]. After that, interval type-2 fuzzy DEMATEL Analytical Network (IT-2 DANP) is extended in order to determine the weights of components. Such a combination is necessary to determine the weights, however had not been observed before. Sustainable components' priorities in planning are identified more accurately as such. This makes the strategic planning for sustainable airports' development more precise and that is why such approach is really needed, essential and unique.

2. Theoretical Background

2.1 Sustainable transportation definition

The concept of sustainable development as a whole has evolved over time. The United Nations World Commission on Environment and Development released a report called Our Common Future which is also known as the Brundtland report in 1987. The report presented a definition about sustainable development which is widely used. Sustainable development is known as a kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs [16, 17]. Since then the sustainable development concept has been used in various systems such as urban development, agriculture and transportation [18, 19].

There are various but similar definitions of sustainable transportation. Sustainable transportation which is sometimes called green transportation is any form of transportation that does not use or rely on declining natural resources. Instead, it is dependent on renewable or regenerated energy rather than fossil fuels [20]. A sustainable transportation system is one that allows the basic access and development needs of society to be met safely and in a manner consistent with human and ecosystem health. It promotes equity within and between successive generations. It is affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development. It limits emissions and waste within the absorption capability of the planet, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise [21].

But that is not all. First of all, it is better to have a closer look at the current situation of the transportation system and its growth. Although there is the additional requirement for transportation infrastructure to improve access to jobs and social welfare or economic and social development, the growth of transportation systems as a whole is notable [22]. Because of that, many authorities are now cooperating with various stakeholders to plan and operate a transportation system that supports environmental, economic and social objectives in addition to the objective of mobility. These include protecting natural resources, improving public health, strengthening energy security, expanding the economy, and providing mobility to disadvantaged people [21].

Previous studies shed the light on this matter that poor growth of transportation systems has often caused different kinds of environmental emissions or disproportionate economic growth. As a result, the focus of transportation has shifted from moving goods or people to supplying needs. The new approach is called Avoid- Shift- Improve (ASI) [22]:

- Avoidance refers to the need to improve the efficiency of the system. Avoidance of unnecessary travel or shortening the trip length becomes possible by making some plans like integration of land use and transportation policies.
- Shift component considers trip efficiency. Travelling with the aid of the most efficient mode makes the dream of shifting from the most energy consuming transportation mode towards more environmentally friendly modes become a reality. In this case non-motorized vehicles or public ones are most suitable for moving people.
- Improve component focuses on improvement of transportation infrastructures by technology advancement and usage of renewable energy.

The ASI approach is comprehensive and coherent and has the potential to contribute to emission reductions and climate change more than expectations. It allows decision makers to set policies that support the mitigation of climate change. Also it is useful for defining strategies to make transport systems more resilient and effective in disaster risk management [23].

Such definitions and approaches are expandable to different modes of transportation or their components. For example, airports play an indispensable role in aviation and social, economic and environmental impacts are inherent to their operations [7]. In this regard, a sustainable airport is the one that is managed so as to ensure the integrity of the economic viability, operational efficiency, natural resource conservation and social responsibility realization [24, 25].

In the long term, airports with powerful economic structures which can meet the social needs of stakeholders and minimize negative environmental impacts can be sustainable. In the short term, they should be competitive to sustain economic viability while preserving natural and human resources to provide continuity for the next generations' needs [26].

2.2 Airports sustainability components

The advantages of going green have led various agencies to make ongoing efforts toward implementing more sustainable airports. In this way, comprehensive sets of components are determined which help airports to be more sustainable paying attention to different operational, maintenance, environmental and social aspects. A set of components has been specified by studying diverse previous research. These components are finalized by performing interval type-2 fuzzy Delphi technique in 2 rounds and through asking the opinions of 7 experts from civil aviation organization in Iran and the Iran airport holding company. These experts are familiar with the concept of airport sustainability and the situations of Iran airports. They also have experiences such as cooperating in determination of airports visions. Each component is as a whole considered. However components contain different sub-components and also many practices. The final components considered in this study are shown in Table 1.

Table 1
Airports sustainability components considered in this study

Code	Component	Resources
Components with the main focus on internal functions of airport		
C1	Policy making	[3, 10, 27, 28, 29; 30; 31]
C2	Coordination	[5, 30, 32, 33, 34, 35, 36, 37, 38]
C3	Commerce	[29, 31, 39, 40, 41, 42, 43, 44]
C4	Human Resources	[5, 9, 10, 30, 37]
C5	Safety and Hygiene	[6, 9, 10, 29, 30, 45, 46]
C6	Security	[5, 30, 47, 48]
C7	Research and Development	[5, 10, 30, 33, 37, 49, 50]
C8	Design of the airport environment	[6, 10, 28, 29, 32, 34, 37]
C9	Construction at the airport	[6, 10, 28, 29, 39, 51]
Components with the main focus on society		
C10	Social Responsibility	[5, 10, 29, 30, 35, 40, 52]
C11	Environmental Pollutants Levels	[3, 28, 39, 53, 54, 55, 56]
Components with the main focus on passengers		
C12	Service Quality	[9, 10, 30, 58, 59]

As mentioned before, components shown in Table 1 are general and contain different sub-components. For more description it should be mentioned that policy making (C1) determines the whole direction of the administration system. Obviously, creating and following up mission and vision statements of the whole airport with respect to sustainability can have an effect on other operations of the system. Besides, a written description of each project and determination of the sustainability vision statement by the project manager can be helpful in better specification of the orientation [10, 29]. Definition of strategic roadmaps consistent with sustainable principles for main operations such as optimal equipment maintenance, research and development, security of passengers and also integration of environmental and biodiversity issues with annual planning and policy can be fruitful [27].

In this way, it is better to set sustainability standards and determine the details related to them for the implementation of sustainability measures in regard to airport operations and details of contracts with contractors, suppliers or exhibitors at the airport. Certainly, international standards should be considered. The principles of ISO 26000 which relates to social responsibility, ISO 5001 which relates to energy management or ISO 14064 which is about greenhouse gases can be helpful [28, 49]. Although Occupational Health and Safety Management System (OHSAS) and Health, Safety and Environment (HSE) are not part of ISO standards, they can be helpful in safety and hygiene improvement [28].

Paying attention to such orientation, the development of internal and external communication plans to inform the public about the performance of sustainability or regularly reporting activities carried out in line with sustainable development and stating sustainability goals associated with each project in simple language that people can easily understand becomes important [10].

Another matter that is related to policy making (C1) is about efficient usage of airport capacity. Trying to predict the exact number of passengers annually, the number of passengers per hour and the number of trips generated by the escort and the greeters are helpful for efficient use of airport capacity. Creation of a flexible development plan in accordance with the needs of growth, technological change and the types of aircraft in the future is necessary too [31].

Good governance can also be important since it can set the trend of administration. It should be mentioned that good governance as a whole describes the process of decision making and the process by which decisions are implemented or not. It can be said that all forces that can influence human behavior are potential tools of governance [28].

Environmental good governance is a branch of good governance. Environmental good governance can be said to be the right to use of natural resources and the environment. The definition of environmental governance includes such norms and values, policies, technologies and organizations through which sustainable economic growth and social development are achieved by managing natural resources in a transparent, accountable, participatory and equitable manner [61].

Coordination (C2) is the second component in Table 1. Working with local, regional and national planning agencies can be helpful to align with the official goals of government [10, 30]. It is useful to increase cooperation with private agencies based on public-private partnership contracts in order to improve efficiency and flexibility of operations [30].

Expansion of cooperation with airlines, air navigation services, aircraft manufacturers and maintenance companies with the objective of the adoption of a coordinated policy in terms of trade, services and preserving the environment should not be ignored. Comprehensive cooperation with other transport systems in the manner and timing of providing services is important too. As a whole, all parts of the supply chain should try to be coordinated in providing services and shaping sustainability. Without cooperation, sustainability cannot be realized properly [10, 48].

Commerce (C3) is an important component for airports. Airport managers should prepare a comprehensive business plan in accordance with the principles of sustainability. In addition, a brand management plan should be prepared so that it becomes assured that commercial policy as an important economic center is in line with the trade policy of the area [29, 40].

Nowadays, airports rely on non-aviation revenues more than before. So, working with media can be helpful in presenting business plans and promoting the products and services of the tenants. Giving business executives the permission to promote their brand at the airport is an opportunity for attracting tenants and increasing revenue from non-aviation sources. However, a committee should be specified to ensure the quality of products and services of those who want to rent part of the airport space based on predetermined standards [31].

Airport is like other organizations in many ways. This is why human resources (C4) play a great role in running its functions. This component consists of some critical matters such as justice in dealing with staff, training and evaluation of staff and communicating with them [5, 10, 33]. In other words, the health and welfare of all staff should be supported equally and racial, ethnic and religious diversity should be respected in a way that opportunity for equitable development for all employees emerges. At the same time, a systematic program should be established to develop skills and knowledge in a manner consistent with the overall objectives of the airport so employees can face the challenges of environmental and competitiveness simultaneously. Sustained attention should be applied to ensure how staff performance is aligned with business strategy. Simultaneously, administrators should have a close relationship with employees in order to be able to solve their needs correctly [9, 30].

Safety and hygiene (C5) constitutes the next component. Training about safety and hygiene is about training for all senior managers and usage of basic training methods to prevent the spread of illness among employees and passengers by application of billboards or other appropriate methods for each group. For example all construction area staff must have safety course certifications [10].

Cultural programs to enhance staff and passenger attention to the issues of hygiene and safety and establish specific procedures for exchange of information related to hygiene and safety at the airport is useful in improving awareness about the importance of safety and hygiene matters [6, 10].

It should be noted that in order to implement safety and hygiene, the current level must be determined first. General and periodic inspections to ensure that the status of employees is consistent with the health and safety program and creating a clear process to document the data gathered through audit and inspection reports can be a great help in this matter [29].

Designating some places for providing sanitation for staff, especially staff of construction areas, such as places for taking showers or changing clothes and providing health and personal protective equipment are certainly required [10, 37].

The establishment of a security system is also undoubtedly important. The security (C6) component refers to the establishment of a security system which can provide the security of the passengers and the whole system while causing minimum inconvenience. In this way, it would be useful to set up structured security management systems run by security senior management to ensure the effectiveness, efficiency and appropriateness of the security system [30, 37].

Research and development (C7) can be helpful in making other components work better. Although investment in research into the improvement of passenger security systems and investment in conducting studies on appropriate technology development for optimal management of air traffic are necessary, cooperation with other airports, transportation systems and research institutions to exchange information and research achievements in such areas as safety and security is also useful [5, 49].

Design of the airport environment (C8) refers to landscape and interior design with the goal of reducing energy consumption while maintaining the beauty of the environment. Considering visual pollution and using colors or plants in a correct way can make this objective achievable. It is better to use plants that are compatible with the climatic conditions of the region. Air conditioning can facilitate this too [10, 28, 29]. In addition, the space should be designed in a way that usage of daylight and air conditioning become possible without any harmful effect on individuals. The use of panels in sufficient number, size and appropriate readability containing a brief message doesn't cause visual pollution and is also beneficial for users [6, 51].

Another matter that can cause pollution is related to construction at the airport (C9). Therefore, contractors with sufficient experience in the field of sustainable construction, with priority given to contractors and suppliers in the area, should be chosen to do the work [10, 29, 51]. Of course, the expected requirements of sustainability should be announced to contractors at the beginning and equipment with lower emissions should be used during construction. It is important to reuse materials and equipment and to not use hazardous chemicals as much as possible. Finally, it should be mentioned that traffic management during construction is also important and can keep the environment calm [6, 28].

So far, most activities have been related to airport operations. But airport functions are not limited only to these. Airports like other organizations have special responsibilities towards the community. Social responsibility (C10) is about communication with stakeholders, support of the people and culture of the region and raising awareness about the importance of sustainability and preserving environmental resources [10].

In this way, it is better to put stakeholders into groups and communicate regularly with each of them in order to communicate the progress of activities in suitable ways such as publishing newsletters [10].

Supporting locals with finding jobs, improving their skills, investment in local projects and holding special events to promote the local and national culture are among other social responsibilities of airports [3, 9].

In addition, holding training courses for employees and members of the public, especially children, regarding the topic of aviation and sustainability through means such as communication with schools should be considered. Training programs in the field of environmental ethics using appropriate methods such as social media or training courses are other social activities that can be very useful in informing the community [60].

Another aspect of airport responsibility can be considered to be environmental pollutants levels (C11). There has been increasing demand, from different agencies, for usage of renewable energy sources instead of non-renewable ones. Taking advantage of the equipment with fuel cells, batteries, electronic or hybrid engines to reduce CO_2 emissions and NO_X can be very beneficial. Using appropriate technology in order to continuously control the amount of air pollution generated by the airport as well as cooperating with other institutions and groups involved in environmental protection to help reduce emissions are other advantageous activities [10, 49].

However, air pollution is not the only pollution that must be under consideration. Noise, light and water pollution are also important. Usage of appropriate insulation for noise pollution reduction, preparing a timetable for determining the times that artificial lighting is really necessary and reducing water consumption through the use of high technology such as electronic-eye faucets are appropriate actions to reduce these forms of pollution [5].

Because waste disposal can be harmful to the environment it is important to ensure that all employees are familiar with the principles of waste management. This includes the grouping and separation of waste at source and the disposal of waste that can transmit infectious diseases under the supervision of an expert. The reason for its importance is that waste disposal can also be harmful for the environment [6].

The last component is service quality (C12) which is directly about passengers. The service provided must be reliable and must meet passenger's needs. This means that airports must have the ability to provide what is promised and the necessary facilities [33]. The availability of both necessary and recreational facilities such as toilets, baby changing rooms, post office and parking with sufficient capacity needs to be considered. Informing passengers of their rights, such as those penalties that airport management should suffer for flight delays must also be considered [59].

3. Research methodology

As it is observable from literature, most the studies have just focused on a special aspect of sustainable development concept such as preserving environment or paying attention to social responsibility. However, considering different components of this concept can be really helpful for airport's functions assessment. This can be seen as a gap in the literature. Hence, a literature review and interval type-2 fuzzy Delphi technique are performed to determine a set of components that can contribute to the sustainability of airports especially in developing countries that do not have much experience in this domain. As a result, adoption of the sustainability concept and determination of its current level can be facilitated in developing countries such as Iran. Since the main focus of this study is not on Delphi technique, just total steps of interval type-2 fuzzy Delphi is depicted in figure 1.

After that, special techniques are used in two steps in order to gather more information about components and make the sustainability implementation easier at airports. DEMATEL technique is performed as the first step to obtain more information about the relationships among the components. In this way, the components can be divided into cause and effect groups. The cause group includes the components that have greater impact on other components of the system, while components in the effect group are those affected more. Thus management of the components in the cause group will make the components in the effect group be directed in a desired way. However, interval type-2 fuzzy sets are considered to better deal with ambiguity in the decision-making process.

It is also obvious that determination of the weights of components can show their priorities in planning. DEMATEL and ANP techniques (which can be called DANP in short) are combined with each other in order to consider the mutual relationships of components in determination of their weights. However, the importance of interval type-2 fuzzy set extension of DANP is clear.

Consideration of interval type-2 fuzzy set theory is essential in order to become capable to deal with ambiguity in experts' opinions and face criticisms about this matter that the membership function in ordinary fuzzy sets which can be called Type-1 fuzzy set does not indicate any uncertainty [62, 63].

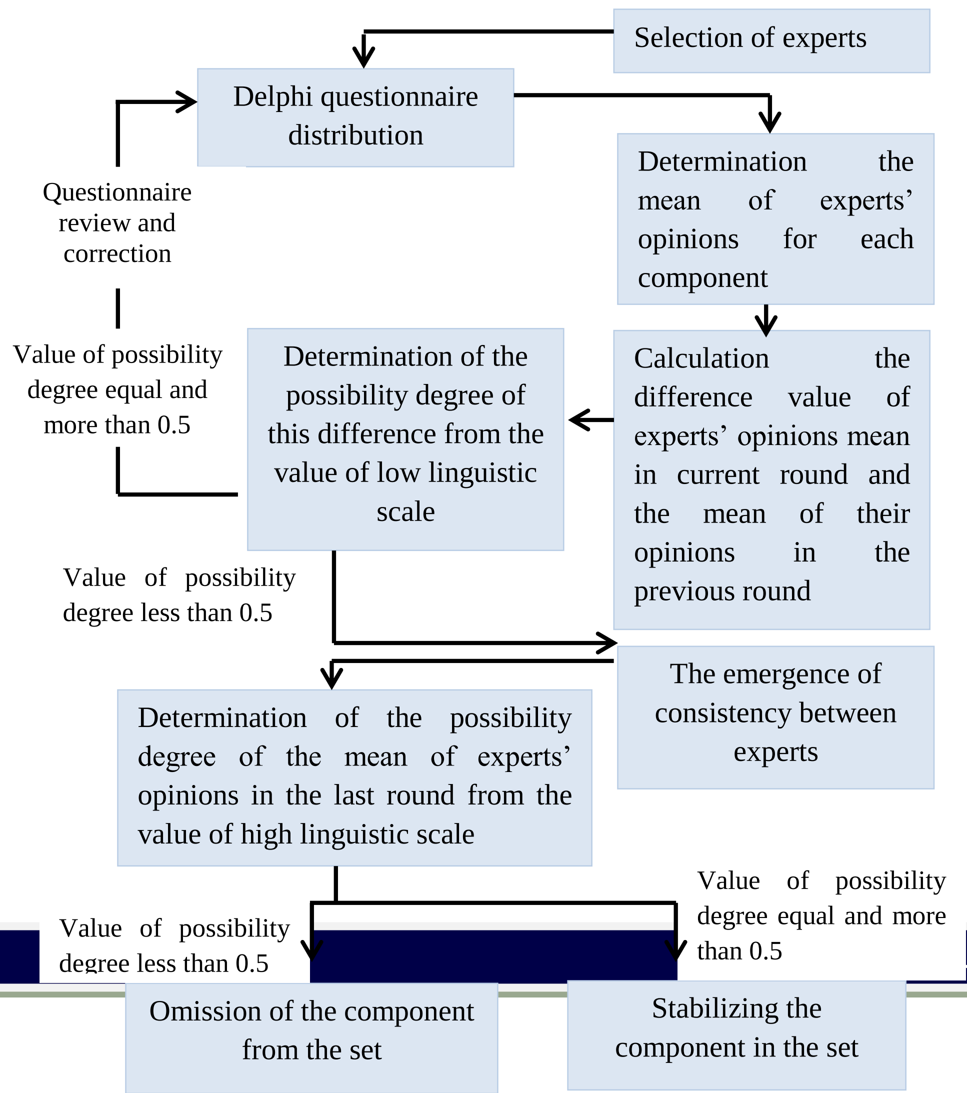

Fig. 1. Total steps of interval type-2 fuzzy Delphi

In order to investigate the necessity of developing sustainable airports in Iran and to further understand sustainability components, experts from civil aviation organization in Iran and the country's airport holding company are asked their opinions. Sustainability components must be under consideration in these companies and these companies are the ones that need to investigate the importance of sustainability, ranks and priority of sustainability components in order to come up with a decision. For this reason, 12 senior managers such as the planning manager are selected from these organizations as decision makers to determine the components' mutual relationships and their ranks (Components are shown in Table 1). Data have been gathered based on the questionnaire measurement tool.

4. Research analysis and results

4.1 Application of interval type-2 fuzzy DEMATEL

In order to determine the mutual relationship between the components depicted in Table 1, the DEMATEL technique is combined with the Interval type-2 fuzzy sets. Interval type-2 fuzzy DEMATEL (IT2 DEMATEL) with the aid of structural modeling approach divides the components into two separate groups- cause and effect. Components that affect other components of the system (the cause group) are differentiated from the ones that are affected by others (the effect group) in this way [64].

IT2 DEMATEL is developed by Abdullah and Zulkifli (2015). Its main steps are the same as the traditional one. Showing the interval fuzzy number with ((a,b,c,d;e,f), (g,h,i,j;k,l)), then matrices with names Xa, Xb, Xc, Xd, Xg, Xh, Xi and Xj must be calculated at each step. This is the main difference between the traditional DEMATEL and the IT2 DEMATEL.

The magnitude of impact each component has on others is determined by each expert. The opinions are integrated by averaging the individual expert scores (equation 1) and initial direct relation matrix (A) is thus determined (H is the number of experts). As said before, there will be 8 matrices, considering the 8 elements of interval type-2 fuzzy number.

$$A = \frac{1}{H}\sum_{k=1}^{H} x_{ij}^{k} \qquad (1)$$

Initial direct relation matrix is normalized by paying attention to equation 2 where S is the maximum aggregate amount of rows and columns of matrix A. The aggregate amount of rows shows the amount of effect each component has on others while the aggregate amount of columns illustrates the amount of effect each component receives from others (see Table 3 and 4).

$$Z = \frac{A}{s} \qquad (2)$$

$$s = \max(\max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}, \max_{1 \le i \le n} \sum_{i=1}^{n} a_{ij})$$

Total relation matrix (T) is obtained at the next step (equation 3). Similarly, different matrix T's (Ta, Tb, Tc, Td, Tg, Th, Ti and Tj) are obtained. I is the identity matrix at equation 3.

$$T = Z(I - Z)^{-1} \tag{3}$$

For providing the cause - effect graph, the total sum of each column and row of the total relationship matrix (called in turn R and D) is obtained. The higher value of (R+D) means that the relevant component has more interaction (or relationships) with other components and as a result, gets a lot of importance. When (D–R) has a positive value, it can be said that this component has more of an effect on others and vice versa. Finally, the cause - effect graph is made by drawing the points with the coordinates of (D+R, D–R). Before that, the expected values of interval type-2 fuzzy numbers must be attained by using equation 4. Fuzzy and crisp amounts of (D+R) and (D-R) for each component are respectively shown in Table 2 and Table 3.

$$E(A) = \frac{1}{2}(\frac{1}{4}\sum_{i=1}^{4} A_i^U + A_i^L) + \frac{1}{4}(\sum_{i=1}^{4} H_i^U + H_i^L) \tag{4}$$

Table 2
Fuzzy amount of (D+R) and (D-R) for each component

Code	Component	D+R	D-R
C1	Policy making	(1.2271,1.2474,1.2474,1.3544;1,1) (1.2244,1.2474,1.2474,1.2873;0.9,0.9)	(1.0709,1.1962,1.1962,1.2446;1,1)(1.0756,1.1962,1.1962,1.2057;0.9,0 .9)
C2	Coordination	(0.4719,0.4852,0.4852,0.5845;1,1) (0.4399,0.4852,0.4852,0.5148;0.9,0.9)	(0.00335,0.0108,0.0108,0.0191;1,1) (0.0053,0.0108,0.0108,0.0156;0.9, 0.9)
C3	Commerce	(0.2707,0.3032,0.3032,0.3651;1,1) (0.2817,0.3032,0.3032,0.3319;0.9,0.9)	(-0.2515,-0.2792,-0.2792,- 0.2865;1,1) (-0.2597,-0.2792,- 0.2792,-0.2799;0.9,0.9)
C4	Human Resources	(0.4011,0.4479,0.4479,0.5273;1,1)(0.4 087,0.4479,0.4479,0.4869;0.9,0.9)	(-0.0853,-0.0805,-0.0805,- 0.0517;1,1)(-0.907,-0.0805,- 0.0805,-0.0655;0.9,0.9)
C5	Safety and Hygiene	(0.3439,0.3986,0.3986,0.6515;1,1)(0.3 63,0.3986,0.3986,0.4417;0.9,0.9)	(-0.1427,-0.1288,- 0.1288,0.0811;1,1)(-0.1388,- 0.1288,-0.1288,-0.1161;0.9,0.9)

C6	Security	(.3026,0.3644,0.3644,0.5308;1,1)(0.2855,0.3644,0.3644,0.3972;0.9,0.9)	(-0.2132,-0.1894,-0.1894,-0.149;1,1)(-0.2131,-0.1894,-0.1894,-0.1676;0.9,0.9)
C7	Research and Development	(0.5484,0.5809,0.5809,0.6575;1,1)(0.5517,0.5809,0.5809, 0.6188;0.9,0.9)	(0.1214,0.1435,0.1435,0.1495;1,1)(0.1195,0.1435,0.1435,0.1448;0.9,0.9)
C8	Design of the airport environment	(0.5313,0.5311,0.5311,0.5574;1,1)(0.4682,0.5311,0.5311,0.5653;0.9,0.9)	(-0.0459,-0.0233,-0.233,-0.0768;1,1)(-0.0458,-0.0233,-0.0233,-0.0205;0.9,0.9)
C9	Construction at the airport	(0.36,0.3688,0.3688,0.4449;1,1)(0.3613,0.3688,0.3688,0.4214;0.9,0.9)	(-0.0129,-0.058,-0.058,-0.0527;1,1)(-0.0599,-0.058,-0.058,-0.07;0.9,0.9)
C10	Social Responsibility	(1.1258,1.1927,1.1927,1.3488;1,1)(1.0825,1.1927,1.1927,1.2655;0.9,0.9)	(0.7048,0.7891,0.7891,0.7782;1,1)(0.6875,0.7891,0.7891,0.7647;0.9,0.9)
C11	Environmental Pollutants Levels	(0.6787,0.7063,0.7063,1.0274:1,1)(0.6897,0.7063,0.7063,0.7876:0.9,0.9)	(-0.6595,-0.6551,-0.6551,-0.5974;1,1)(-0.6695,-0.6551,-0.6551,-0.6012;0.9,0.9)
C12	Service Quality	(0.6146,0.696,0.696,0.8464;1,1)(0.6741,0.696,0.696,0.7733;0.9,0.9)	(-0.7146,-0.696,-0.696,-0.6202;1,1)(-0.6971,-0.696,-0.696,-0.695;0.9,0.9)

Table 3
Crisp amount of (D+R) and (D-R) for each component

Code	C1	C2	C3	C4	C5	C6
Component	Policy making	Coordination	Commerce	Human Resources	Safety and Hygiene	Security
D+R	1.1973	0.4692	0.2923	0.42935	0.40309	0.35312
D-R	1.1140	0.0102	0.0189	-0.1699	-0.0987	-0.1780
Code	C7	C8	C9	C10	C11	C12
Component	Research and Development	Design of the airports environment	Construction at the airport	Social Responsibility	Environmental Pollutants Levels	Service Quality
D+R	0.55812	0.50428	0.31366	1.13921	0.71352	0.6759
D-R	0.1317	-0.0335	-0.0508	0.7233	-0.61133	-0.6544

Based on the crisp values of (D+R) and (D-R), the cause – effect graph is depicted (Fig. 2). Considering the values of (D-R), it can be said that policy making (C_1), social responsibility (C10), research and development (C7), commerce (C3) and coordination (C2) constitute the cause group. All of these components can direct the entire system. However, design of the airport environment (C8), construction at the airport (C9), safety and hygiene (C5), human resources (C4), security (C6), environmental pollutants levels (C11) and service quality (C12) determine the effect group.

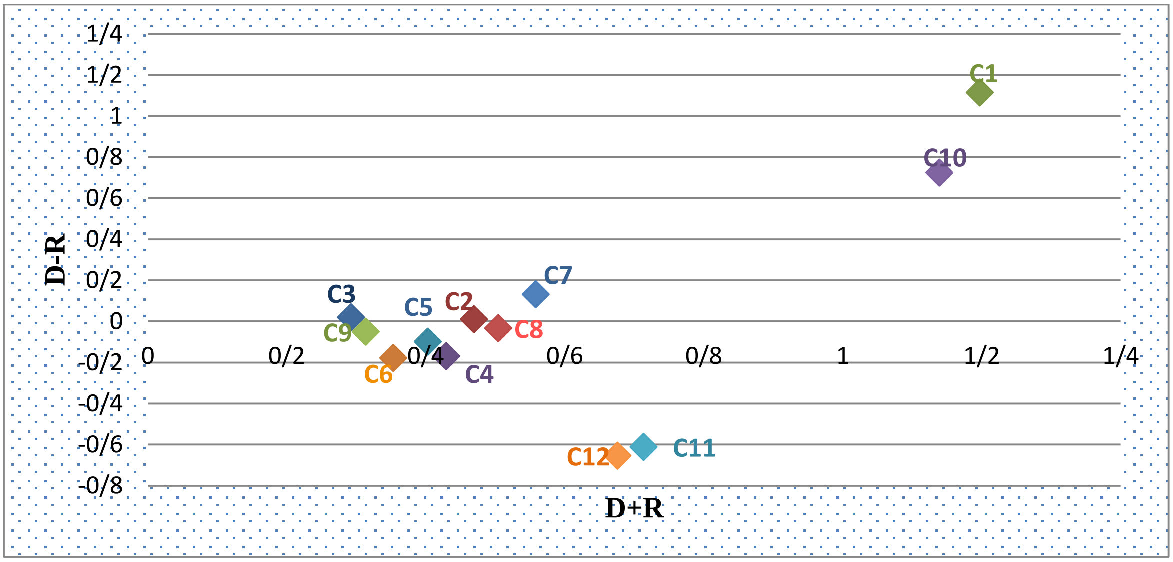

Fig. 2. Cause – effect graph

As is obvious, policy making (C1) has the highest value of (D+R) and social responsibility (C10) is in the second place. This means that these components have the most interactions with the others, while commerce (C3) has the least.

Policy making (C1) and social responsibility (C10) also have the highest value of (D-R). This means that these components have great impact on all the components. By directing the procedure of policy making and implementation of social responsibility in coordination with the concept of sustainability, other components will be directed in a desirable way.

Environmental pollutants levels (C11) and service quality (C12) have the least value of (D-R). It can be said that these components are very much under the influence of other components. This is not unexpected. It is clear that the interior design of the airport space with consideration to the air conditioning and the usage of sun light in a relaxing way can cause pollutant levels to be decreased. Besides, paying attention to matters such as social responsibility can cause service quality to be increased (Atlanta International Airport, 2015).

4.2 Interval type-2 fuzzy set extension of DANP

Analytic Network process (ANP) is an extension of Analytical Hierarchy Process (AHP) that has the capability to include all the relevant components in arriving at a decision. In many cases, interdependence exists among components and interactions among the components of a system set a network structure. In these cases, AHP cannot be helpful while ANP can provide an effective tool via a super-matrix approach [65, 66].

ANP can determine the weights of the components. In this regard, it can be made clear which component should receive more attention in the context of sustainability. First of all, it should be mentioned that the ANP technique is based on experts' opinions and because of this, interval type-2 fuzzy sets are considered in this section too. Experts are asked to evaluate all proposed components pairwise.

Components are compared pair-wise with respect to their importance towards the objective of making airports sustainable. That is, $a_{ij}=1/a_{ji}$, where a_{ij} denotes the importance of the i^{th} component. Pair-wise comparison is made in the framework of a matrix, and an eigenvector can be derived as an estimate of relative importance associated with the components being compared by solving equation 5 [67].

$$A \times w = \lambda_{\max} \times w \qquad (5)$$

There will be 8 matrices in each step considering the 8 elements of the interval type-2 fuzzy numbers. Lastly, the eigenvector (shown in Table 4) in companion with the total relationship matrix in the DEMATEL technique will constitute the super-matrix. This is why the technique is called DANP. In this way, the amount of affection components have on each other can be included in determination of their weights. The Supermatrix for the first element of interval type-2 fuzzy number is shown in Table 5.

Table 4
Eigenvector of components

Code	Eigenvector
C1	(0.2284, 0.2286, 0.2286, 0.2986; 1, 1)(0.2285, 0.2286, 0.2286, 0.2966 ; 0.9, 0.9)
C2	(0.1223, 0.128, 0.128, 0.1258; 1, 1)(0.1223, 0.128, 0.128, 0.129; 0.9, 0.9)
C3	(0.0346, 0.0353, 0.0353, 0.046; 1, 1)(0.0349, 0.0353, 0.0353, 0.042; 0.9, 0.9)
C4	(0.0124, 0.0129, 0.0129, 0.034; 1, 1)(0.01279, 0.0129, 0.0129, 0.026; 0.9, 0.9)
C5	(0.064, 0.0654, 0.0654, 0.081; 1, 1)(0.0645, 0.0654, 0.0654, 0.076; 0.9, 0.9)
C6	(0.064, 0.0654, 0.0654, 0.081; 1, 1)(0.0645, 0.0654, 0.0654, 0.076; 0.9, 0.9)
C7	(0.1104, 0.119, 0.119, 0.1199; 1, 1)(0.1105, 0.119, 0.119, 0.1194; 0.9, 0.9)
C8	(0.043, 0.045, 0.045, 0.0512; 1, 1)(0.044, 0.045, 0.045, 0.049; 0.9, 0.9)
C9	(0.043, 0.045, 0.045, 0.0512; 1, 1)(0.044, 0.045, 0.045, 0.049; 0.9, 0.9)
C10	(0.079, 0.097, 0.097, 0.0995; 1, 1)(0.079, 0.097, 0.097, 0.098; 0.9, 0.9)
C11	(0.073, 0.075, 0.075, 0.0808; 1, 1)(0.074, 0.075, 0.075, 0.079; 0.9, 0.9)
C12	(0.072, 0.088, 0.088, 0.0893; 1, 1)(0.073, 0.088, 0.088, 0.088; 0.9, 0.9)

Table 5
Supermatrix for the first element of the interval type-2 fuzzy number

	objective	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
objective	0	0	0	0	0	0	0	0	0	0	0	0	0

C1	0.046	0.0024	0.0023	0.002	0.0023	0.0023	0.0024	0.002	0.0024	0.0022	0.0007	0.0092	0.0089
C2	0.1158	0.0143	0.0043	0.002	0.0137	0.0098	0.0141	0.013	0.0137	0.0038	0.0111	0.0914	0.0906
C3	0.1786	0.1137	0.1087	0.006	0.1092	0.1085	0.114	0.104	0.1099	0.1042	0.1082	0.1635	0.1486
C4	0.034	0.0148	0.0105	0.002	0.0049	0.0142	0.0149	0.013	0.0143	0.0136	0.0181	0.0479	0.0684
C5	0.081	0.0081	0.0062	0.002	0.0192	0.0058	0.0425	0.004	0.0484	0.0046	0.0189	0.1721	0.0331
C6	0.081	0.0439	0.0396	0.002	0.0172	0.0039	0.0043	0.003	0.0041	0.0036	0.0112	0.0172	0.0396
C7	0.1109	0.0174	0.017	0.012	0.0167	0.0166	0.0174	0.010	0.0168	0.0159	0.0765	0.0944	0.0916
C8	0.0512	0.0035	0.0033	0.002	0.0032	0.0124	0.0129	0.002	0.0034	0.0028	0.0131	0.0944	0.0992
C9	0.0512	0.0035	0.0033	0.002	0.0032	0.0124	0.0129	0.002	0.0034	0.0028	0.0041	0.096	0.0493
C10	0.0855	0.0974	0.1	0.014	0.0935	0.0929	0.0977	0.089	0.0941	0.0891	0.0159	0.1511	0.1279
C11	0.0808	0.0034	0.0033	0.002	0.0032	0.0032	0.0034	0.003	0.0033	0.0031	0.0103	0.0126	0.014
C12	0.0813	0.0034	0.0033	0.002	0.0032	0.0032	0.0034	0.003	0.0033	0.0031	0.0103	0.0126	0.0121

After that, each supermatrix should be made normal by the Saaty method (equation 6). The Limit supermatrix can be obtained by raising the normalized supermatrix to powers until all the elements of each row become equal to other numbers of that row. The numerical value of each row of the supermatrix is the weight of each component. The interval type-2 fuzzy weight of each component is obtained by calculating the 8 limit supermatrix. Table 6 points to these weights and their equivalent crisp numbers.

$$r_{ij} = \frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}}$$

(6)

Table 6

Interval type-2 fuzzy weight of each component and its equivalent crisp numbers

Code	Interval type-2 fuzzy weight	Equivalent crisp weight	Rank
C1	(0.3146,0.3396,0.3396,0.337;1,1) (0.3341,0.3396,0.3396,0.3344;0.9,0.9)	0.318071875	**1**
C2	(0.0251,0.0299,0.0299,0.0542;1,1) (0.0284,0.0299,0.0299,0.0417;0.9,0.9)	0.03194375	**4**
C3	(0,0,0,0.0129;1,1)(0,0,0,0.0101;0.9,0.9)	0.00273125	**12**
C4	(0.0238,0.0298,0.0298,0.0479;1,1) (0.0282,0.0298,0.0298,0.0448;0.9,0.9)	0.031338125	**6**
C5	(0.0134,0.0349,0.0349,0.0663;1,1) (0.0135,0.0349,0.0349,0.0355;0.9,0.9)	0.031860625	**5**
C6	(0.0013,0.0032,0.0032,0.0481;1,1) (0.0017,0.0032,0.0032,0.0225;0.9,0.9)	0.01026	**8**
C7	(0.2337,0.2756,0.2756,0.2962;1,1) (0.2752,0.2756,0.2756,0.2921;0.9,0.9)	0.2612025	**3**
C8	(0.0026,0.0045,0.0045,0.0391;1,1) (0.0027,0.0045,0.0045,0.0317;0.9,0.9)	0.011174375	**7**
C9	(0.0001,0.0009,0.0009,0.032;1,1) (0.0008,0.0009,0.0009,0.0191;0.9,0.9)	0.0066025	**9**
C10	(0.2994,0.3046,0.3046,0.3587;1,1) (0.3045,0.3046,0.3046,0.3583;0.9,0.9)	0.301541875	**2**
C11	(0,0,0,0.021;1,1)(0,0,0,0.0173;0.9,0.9)	0.004548125	**10**
C12	(0,0,0,0.0208;1,1)(0,0,0,0.017;0.9,0.9)	0.00448875	**11**

As depicted in Table 5, policy making (C1), social responsibility (C10) and research and development (C7) have the first, second and third rank. While, environmental pollutants levels (C11), service quality (C12) and commerce (C3) have the last three ranks. This result can be explained in the following way. Policy making (C1) determines the whole direction of a system and is truly dependent on the decision makers' knowledge. This knowledge is also affected by research and development (C7). Besides, social responsibility is a concept which is very much under consideration in society. It is known that paying attention to social responsibility improves an organization's reputation [3].

Environmental pollutants levels (C11) and service quality (C12) receive the greatest impact from other components. That is why they have the lowest ranks. But, there is something different about commerce (C3). Non-aviation income has recently received attention in developing countries such as Iran. It does not mean that this component is not important. Experts confirm this result.

5. Managerial implications

Airports' managers can benefit from components introduced in this study (Table 1) and use them as a roadmap to achieve a consensual understanding of the best way of achieving sustainability. Airports can identify new ways to improve their functions according to the priority of mentioned components that shed the light on matters such as reduction of environmental pollutants levels and increasing service quality, resulting in savings in resources and cost and improving corporate reputation. Also, it reveals the strengths and weaknesses of the current situation of airports from the viewpoint of sustainability. In addition, the proposed approach can be used to set better processes and cooperation with the governmental and private partners. This viewpoint can cause partners to improve certain defects and move towards promotion of sustainability of airports.

6. Conclusion

The main objective of this study was to propose a comprehensive set of components to investigate the concept of sustainability at airports by taking advantage of interval type-2 fuzzy DEMATEL and interval type-2 fuzzy DANP. This paper contains interesting contributions as below:

- Components related to sustainability of airports are investigated based on experts' opinions. A succinct yet comprehensive set of components is determined in this way that is matched with situation of airports in developing countries like Iran. This makes it possible to have a clear and deep perception of critical success components influencing the sustainability of airports.
- This study applied interval type-2 fuzzy DEMATEL for determination of the mutual relationships of components. It becomes clear that "policy making" and "social responsibility" are the components that can affect the other ones. It is obvious that by directing these components; other components of the system can be directed in the same path. Such analysis about the components related to sustainability of airports has not been observed before.
- Interval type-2 fuzzy DANP is extended for the first time to specify the weights of components. Thus, not only the interaction between the components is determined, but their priority is distinguished in a way that uncertainty and fuzziness remains in the whole steps of the technique. This enhances the accuracy of the calculations. In this way, the

knowledge of decision makers about sustainability is improved and they also understand how they should move toward shaping a sustainable airport. Results reveal that paying full attention to policy making at airport management and implementing social responsibility are in the highest priorities at the moment.

This study raises the possibility of carrying out several studies in the future. Future studies could concentrate on evaluation of airports' sustainability performance paying attention to such components and taking advantages of techniques such as Data Envelopment Analysis (DEA) and Malmquist index. In this way, airports can determine their path through success by suitable benchmarking and administration. Such an investigation is necessary through the whole parts of the air transportation value chain too. This increases coordination and improves service quality.

References

1. Carter, C.R. and Rogers, D.S. (2008), "*A framework of sustainable supply chain management: moving toward new theory*", International Journal of Physical Distribution & Logistics Management, **38** (5), pp 360‑387.
2. Lee, C.K.M.and Lam, J.S.L. (2012), "*Managing reverse logistics to enhance sustainability of industrial marketing", Industrial Marketing Management*, **41** (4), pp 589–598.
3. International Civil Aviation Organization (ICAO) (2012), "*Sustainable Future for Aviation: ICAO Rio+20 Global Initiative*", Retrieved 13 April 2016 from http://climate-l.iisd.org/news/icao-publishes-booklet-for-rio20-decision makers.
4. Sustainable Aviation (SA) (2013), "*The Sustainable Aviation Progress Report 2013*", Retrieved 13 April 2016 from www.sustainableaviation.co.uk.
5. Advisory Council for Aeronautics Research in Europe (ACARE) (2011), "*Flight path 2050 Europe's Vision for Aviation*", Luxembourg: Publications Office of the European Union.
6. Airport Cooperative Research Program (ACRP) (2011), "Sustainable Airport Construction Practices", The Federal Aviation Administration.
7. Koç, S. and Durmaz, V. (2015), "*Airport Corporate Sustainability: An Analysis of Indicators Reported in the Sustainability Practices*", Procedia - Social and Behavioral Sciences, 181, pp 158 – 170.
8. Chang, A.S. and Tsai, C.Y. (2015), "Sustainable design indicators: Roadway project as an example", Ecological Indicators, 53, pp 137–143.
9. Heathrow airport (2015), "*Responsible Heathrow*", Retrieved 13 December 2016 from http://www.heathrow.com/company/community-and-environment/responsible-heathrow.
10. Sustainable Aviation Guidance Alliance (SAGA) (2016), "*Sustainability Database*" Retrieved 13 April 2016 from http://www.airportsustainability.org/database.
11. Transportation Research Board (TRB) (2015), "*TRB Webinar: Airport Sustainability Practices and Strategies*", Retrieved 13 April 2016 from http://www.trb.org/Calendar/Blurbs/169268.aspx.
12. Lam, J.S.L. (2015), "*Designing a sustainable maritime supply chain: A hybrid QFD–ANP approach*". Transportation Research Part E: Logistics and Transportation Review, 78, 70-81.

13. Jeon, C.M. (2007), "*Incorporating Sustainability into Transportation Planning and Decision Making: Definition, Performance Measures and evaluation*", Ph.D. thesis, School of Civil and Environmental Engineering, Georgia Institute of Technology.
14. Kolak, O.J., Akın, D., Birbil, I., Feyzioglu, O. and Noyan, N. (2011), "*Multicriteria Sustainability Evaluation of Transport Networks for Selected European Countries*", Proceedings of the World Congress on Engineering I.
15. Kahraman, C., Öztaysi, B., Ucal Sarı, I. and Turanog¢lu, E. (2014), "*Fuzzy analytic hierarchy process with interval type-2 fuzzy sets*", Knowledge-Based Systems, 59, pp 48–57.
16. World Commission on Environment and Development (1987), "*Our Common Future*" Retrieved 13 April 2016 from www.un-documents.net/our-common-future.pdf.
17. Banerjee, S.B. (2002), "*Organizational Strategies for Sustainable Development: Developing A Research Agenda for the New Millennium*" Austrian Journal of Management, 27 (1), pp 105-117.
18. Bolcárová, P. and Kološta, S. (2015), "*Assessment of sustainable development in the EU 27 using aggregated SD index*", Ecological Indicators, 48, pp 699–705.
19. Al-Atawi, A.M., Kumar, R. and Saleh, W. (2016), "*Transportation sustainability index for Tabuk city in Saudi Arabia: an analytic hierarchy process*", Transport, **31** (1), pp 47-55. http://dx.doi.org/10.3846/16484142.2015.1058857.
20. Evans, M. (2011), "*Sustainable Transport*", Retrieved 13 April 2016 from http://www.earthtimes.org/encyclopaedia/environmental-issues/sustainable-transport.
21. Ridley Pryn, M., Cornet, Y. and Bang Salling, K. (2015), "*Applying sustainability theory to transport infrastructure assessment using a multiplicative ahp decision support model*", Transport, **30** (3), pp 330-341. http://dx.doi.org/10.3846/16484142.2015.1081281
22. United Nations Conference on Sustainable Development (UNCSD) (2012), "*Sustainable, Low Carbon Transport in Emerging and Developing Economies*", RIO 2012 Issues Briefs. Retrieved 13 April 2016 from https://sustainabledevelopment.un.org/content/documents/403brief13.pdf.
23. German International Cooperation (GIZ) (2011), "*Sustainable Urban Transport: Avoid-Shift-Improve (A-S-I). Sustainable Urban Transport Project*", Retrieved 13 April 2016 from http://www.sutp.org/dn.php?file=FS-ASI-EN.pdf.
24. Airports Council International (ACI) (2015), "*Airport Sustainability -A Holistic Approach to Effective Airport Management*", Retrieved 28 December 2015 from http://www.aci-na.org/static/entransit/Sustainability%20White%20Paper.pdf
25. Federal Aviation Administration (FAA) (2015), "*Airport Sustainability*" Retrieved 29 December 2015 from http://www.faa.gov/airports/environmental/sustainability.
26. Artiach, T., Lee, D., Nelson, D. and Walker, J. (2010), "*The determinants of corporate sustainability Performance*", Accounting and Finance, 50 (1), pp 31-51.
27. Organization for Economic Co-operation and Development (OECD) (2001), "*OECD Environmental Strategy for the First Decade of the 21st Century*", Retrieved 10 April 2016 from http://www.oecd.org/env/indicators-modelling-outlooks/1863539.pdf.
28. Airport Cooperative Research Program (ACRP) (2012), "*Guidebook for Incorporating Sustainability in to Traditional Airport Projects*", Washington, DC: TRB.
29. Chicago Department of Aviation (CDA) (2013), "*Sustainable Airport Manual*", Retrieved 13 April 2016 from http://www.airportsgoinggreen.org/sustainable-airport-manual.aspx.

30. International Air Transport Association (IATA) (2014), "*Annual Review 2014*", Retrieved 13 April 2016 from http://www.iata.org/about/Documents/iata-annual-review-2014.pdf.
31. Atlanta International Airport (2015), "*Doing Business with the Airport*", Retrieved 29 December 2015 from http://www.atlanta-airport.com/business/DoingBusiness.
32. Massachusetts Port Authority (MASSPORT) (2009), "*Sustainable Design Standards and Guidelines. Capital Programs and Environmental Affairs Department*", Retrieved 12 April 2016 from https://www.massport.com/media/1042/SustainableDesign_v2_March2011.pdf.
33. European Commission (2011), "*Transport Research and Innovation in Horizon 2020*", Retrieved 20 April 2016 from http://ec.europa.eu/programmes/horizon2020.
34. Oto, N., Cobanoglu, N. and Geray, C. (2012), "*Education for Sustainable Airports*", Procedia - Social and Behavioral Sciences, 47, pp 1164–1173.
35. Carnis, L. and Yuliawati, E. (2013), *Nusantara: Between sky and earth could the PPP be the solution for Indonesian airport infrastructures?*", Case Studies on Transport Policy, **1** (1-2), pp 18-26.
36. Green Sustainable Airports (GSA) (2015), "*GSA Catalogue*", Retrieved 13 April 2016 from http://www.greenairports.eu.
37. European Commission (2013), "*Horizon 2020 -Draft Horizon 2020 Work Program 2014-2015 in the area of Transport*", Retrieved 18 April 2016 from http://ec.europa.eu/research/horizon2020/pdf/workprogrammes/smart_green_and_integrated_transport_draft_work_programme.pdf .
38. Yujin, L. and Zhiyong, Z. (2013), "*Technical Methods of Comprehensive Transportation Plans in the Airport Economic Zone*", Procedia - Social and Behavioral Sciences, 96, pp 182–187.
39. Brisbane Airport Corporation (2009), "*Land Use and Precinct Development*", Retrieved 17 April 2016 from http://www.bne.com.au/sites/all/files/content/files/BACMP09_Chapter_6.pdf.
40. International Civil Aviation Organization (ICAO) (2013), "*Airport Economics Manua",* Retrieved 13 April 2016 from http://www.icao.int/publications/pages/publication.aspx?docnum=9562.
41. South Texas Regional Airport at Hondo (2013), "*South Texas Regional Airport at Hondo Business Plan",* Retrieved 13 April 2016 from www.hondo-tx.org/airport/docs/Hondo_Airport_Business_Plan.pdf
42. Airports Council International (ACI) (2014), "*Airport Commercial and Retail*", Retrieved 13 April 2016 from http://www.aci-europe-events.com/airport-commercial-retail/exhibition.
43. University Park Airport (2014), "*Sustainable airport Master Plan*", Retrieved 10 April 2016 from universityparkairport.com.
44. Orlando International Airport (2015), "*Airport Business*", Retrieved 13 April 2016 from http://www.orlandoairports.net/business.htm.
45. World Health Organization (WHO) (2009), "*Guide to Hygiene and Sanitation in Aviation*", Retrieved 13 April 2016 from http://www.who.int/water_sanitation_health/hygiene/ships/guide_hygiene_sanitation_aviation_3_edition.pdf.
46. Vectair systems (2014), "*Hygiene on the move – considering airports*", Retrieved 10 April 2016 from http://www.vectairsystems.com/blog/hygiene-airports

47. Civil Aviation Authority (CAA) (2011), "*Developing a Sustainable Framework For UK Aviation. Department for Transport Consultation*", Retrieved 14 April 2016 from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/2579/consultationdocument.pdf.
48. European Commission (2015), "*Horizon 2020- Transport*", Retrieved 13 April 2016 from http://ec.europa.eu/programmes/horizon2020/en/area/transport.
49. Zietsman, J. and Ramani, T. (2011), "*Sustainability Performance Measure for State DOTS and Other Transportation Agencies*", Texas Transportation Institute.
50. Giustozzi, F., Toraldo, E. and Crispino, M. (2012), "*Recycled airport pavements for achieving environmental sustainability: An Italian case study*", Resources, Conservation and Recycling, 68, pp 67–75.
51. Lao Angeles World Airports (LAWA) (2010), "*Sustainable Airport Planning, Design and Construction Guidelines for Implementation on all Airport Projects*", Retrieved 13 April 2016 from http://lawa.org/uploadedFiles/LAWA/pdf/Sustainable%20Airport%20PDC%20Guidelines%20Jan08.pdf.
52. National Air Traffic Services (NATS) (2014), "*The NATS Corporate Responsibility Report 2014: The countdown to 2020 has begun*", Retrieved 12 April 2016 from http://www.nats.aero/wp-content/uploads/2015/06/NATS-Corporate-Responsibility-Report-2014.pdf
53. International Civil Aviation Organization (ICAO) (2006), "*Destination Green*", Retrieved 13 April 2016 from http://www.icao.int/publications/journalsreports/2013/6802_en.pdf.
54. International Civil Aviation Organization (ICAO) (2010), "*ICAO Environmental Report 2010, Aviation and Climate Change*", Retrieved 13 April 2016 from /http://www.icao.int/icao/en/env2010/Pubs/EnvReport10.htmS.
55. International Transport Forum (ITF) (2010), "*Reducing Transport Greenhouse Gas Emissions Trends and Data*", Retrieved 13 April 2016 from http://www.internationaltransportforum.org/Pub/pdf/10GHGTrends.pdfS.
56. Miyoshi, C. and Mason, K.J. (2013). "*The damage cost of carbon dioxide emissions produced by passengers on airport surface access: the case of Manchester Airport*", Journal of Transport Geography, 28, pp 137-143.
57. Carvalho, I.D.C., Calijuri, L.M., Assemany, P.P., Freitas, M.S., Moreira, N.R.F., Santiago, A.F. and Batalha de Souza, M.H. (2013), "*Sustainable airport environments: A review of water conservation practices in airports*", Resources, Conservation and Recycling, 74, pp 27–36.
58. Wu C.L. (2010), "*Airline Operations and Delay Managements*", London: Ashgate Publishing.
59. Aéroports de Paris (ADP), (2015), *SERVICES*, Retrieved 13 April 2016 from http://www.aeroportsdeparis.fr/en/passengers/services.
60. London City Airport (2012), *London City Airport Biodiversity Strategy 2012-2017*, Retrieved 12 April 2016 from http://www.londoncityairport.com/content/pdf/LCY43434_PLANAP_Biodiversity%20Strategy_2011%20fv_lg.pdf.
61. Mattor, K., Betsill, M., Huayhuaca, C., Huber-Stearns, H., Jedd, T., Sternlieb, F., Bixler, P., Luizza, M. and Cheng, A.S. (2014), "*Transdisciplinary research on environmental governance: A view from the inside*", Environmental Science & Policy, 42, pp 90-100.

62. Hu, J., Zhang, Y., Chen, X. and Liu, Y. (2013), "*Multi-criteria decision making method based on possibility degree of interval type-2 fuzzy number*" Knowledge-Based Systems, 43, pp 21–29.
63. Abdullah, L. and Najib, L. (2014), "*A new type-2 fuzzy set of linguistic variables for the fuzzy analytic hierarchy process*", Expert Systems with Applications, 41, pp 3297–3305.
64. Abdullah, L. and Zulkifli, N. (2015), "*Integration of fuzzy AHP and interval type-2 fuzzy DEMATEL: An application to human resource management*", Expert Systems with Applications, **42** (9), pp 4397-4409.
65. Saaty, T.L. (1980), "The Analytic Hierarchy Process", Boston: McGraw-Hill, Inc.
66. Xu, P., Chan, EHW., Visscher, HJ., Zhang, X. and Wu, Z. (2015), "*Sustainable building energy efficiency retrofit for hotel buildings using EPC mechanism in China: analytic Network Process (ANP) approach*", Journal of Cleaner Production, 107, pp 378–388.
67. Lam, J.S.L. and Lai, K.H. (2015), "*Developing environmental sustainability by ANP-QFD approach: the case of shipping operations*", Journal of Cleaner Production 105, pp 275-284.