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Evaluating green performance of the airports using hybrid BWM and VIKOR methodology

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ABSTRACT

The aviation industry is growing at a rapid pace worldwide. However, with the growing numbers, the aviation industry has also contributed to environmental degradation over the past few years. This issue needs attention as various agencies and scholars all over the world are trying to find means of protecting the environment. Therefore, there is a growing need to develop green and sustainable airports, which have minimal impact on the environment. With this in focus, this research has been taken up to explore the criteria for evaluating the green performance of airports. A hybrid of Best Worst Method (BWM) and VlseKriterijuska Optimizacija I Komoromisno Resenje (VIKOR) methodologies has been employed to calculate the weight of different criteria and rank the airports accordingly. Green policies and regulations are the most important performance criteria for green airports.

1. Introduction

'Sustainability is no longer about doing less harm, it is about doing more good'. Technological advancement has made human lives more convenient in many ways, but it has resulted in numerous anthropogenic greenhouse gases, and environmental degradation that contributes to global warming. Aviation is one of the fastest growing sectors of the global economy with an average annual growth rate of around 5% over the past 20 years; however, the sector has witnessed a tremendous change in the recent past (Cherry, 2008; Vespermann & Wald, 2011; Voltes-Dorta, Rodríguez-Déniz, & Suau-Sanchez, 2017). The radical change in the practices and policies of the aviation industry has also raised environmental concerns across the world. Further, aviation results in around 2% to the global man-made Carbon dioxide and Carbon monoxide emissions (Noor et al., 2015). But it is expected that the emissions would increase to 3% by 2050 (IPCC, 1999). Along with the increased Carbon dioxide emissions, the other crucial concerns of the sector are noise pollution, waste management, energy conservation, etc. (Ferrulli, 2016; Gasco, Asensio, & de Arcas, 2017; Uysal & Sogut, 2017). Inter-governmental panel on climate change (IPCC) issued a report in 2014, which was published by World Meteorological Organization (WMO). In the report, it is stated that from the last 50 decades, more than half of the factors causing increase in the global average surface temperature are more likely to be an outcome of the augmentation of the anthropogenic greenhouse gas contributions and other pollutants (IPCC, 2014). The data further revealed that approximately one-fourth of global greenhouse gas results from the transport industries, of which the aviation sector accounted for 13%. This has resulted in framing regulations and setting targets for greening the aviation sector. International Air Transport Association (IATA) has designed a landmark policy framework in 2008, which aims to (1) carbon neutral growth with cap on CO_2 emissions starting from 2020, (2) an average improvement of 1.5% carbon efficiency from 2009 to 2020 per annum, and (3) 50% reduction in carbon emissions by 2050 (IATA, 2008; Herndon et al., 2004). In 2014, the European Union (EU) summit adopted a 2030 framework for climate and energy to reduce greenhouse gas emissions by at least 40% by 2030. In the recent times, the focus has further shifted to the effect of aviation activities on climate change (EEA, 2007; EEA, 2012; Thomas, Hooper, & Raper, 2010.

Despite the common belief, it is not the finance or availability of the land that hinders airport growth; rather, the environmental consequences of the construction pose challenge for the airport development (Ferrulli, 2016). This makes the concept of airport environmental capacity an emerging concern for the world (Coleman, 1999; Upham, Thomas, Gillingwater, & Raper, 2003; Thomas, 2013). The Airport Council International (ACI) defines airport sustainability as a 'holistic approach to managing an airport so as to ensure the integrity of the economic viability, operational efficiency, natural resource

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conservation, and social responsibility of the airport' (www.aci-na.org). Sustainability in airports can be achieved only with the correct balance among the socio-economic objectives within the limits imposed by the environment (Kivits, Charles, & Ryan, 2010; Upham et al., 2003).

Green aviation aims to provide a transport system that reduces carbon footprint and harmful pollutants as well as uses renewable energy sources (Noor et al., 2015). Balaras, Dascalaki, Gaglia, and Droutsa (2003) found 35% energy savings potential in 29 airport buildings in Greece that gives a ray of hope for innovative practices and systems in Greening the airports for sustainable development of the world.

India as one of the largest emerging economies in Asia with the world's second largest population opens doors for aviation growth in the coming years. However, the report by Directorate General of Civil Aviation on Carbon footprint of Indian Aviation (DGCA, 2013) raises serious concerns over the sustainable development of Indian airports. The report stated that Indian airports emitted around 780,000 tons of CO_2 in 2013, which was 770,000 tons in 2012. The report also predicted an alarming 28, 000, 000 tons of CO_2 emissions by 2020 in the absence of reduction measures.

India has a potential growing aviation market with more than 100 airports, which handle 170 million passengers annually on an average. It also represents 1.5% of India's GDP by providing 9 million jobs, which will make India the third largest aviation market by 2020. The recent union budget of India 2018–2019 further proposes to increase country's airport capacity to handle up to 1 billion trips per year by 2020, which will initiate drastic infrastructure developmental works in the aviation sector of the country. Development without considering the environmental issues would be really a challenge for the future generation. However, there is a dearth of studies on green airports in the developing countries, especially in the Indian context.

The rising environmental concern about the aviation sector proves that green airports and operations would be the future of sustainable development (Votsi, Mazaris, Kallimanis, & Pantis, 2014). The aviation sector has begun to develop sophisticated methodologies to make green aviation sector a reality. The multi-criteria decision-making (MCDM) approach is a widely adopted and useful technique to deal with the decision-making problems related to multiple criteria. BWM, VIKOR, TOPSIS, ISM, DEMATEL, AHP are some of these techniques. Thus, this paper tries to explore and rank the criteria associated with the implementation of Green practices in Indian airports using the MCDM techniques. The techniques help in identifying the crucial criteria that will help authorities to make Indian airports greener, cleaner, and sustainable by balancing the economic and social aspects.

This study has a three-fold contribution for managers and regulatory authorities. Firstly, the study helps in identifying the barriers in green practices adoption in airports, which are supported by four organizational theories such as resource-based view (RBV), stakeholder theory (ST), institutional theory (IT), and ecological modernization theory (EMT). Secondly, this study is one of the few studies conducted in the Indian context, and it will help airport managers and government to frame suitable policies. Finally, the current study uses a novel methodology comprising of the BWM and VIKOR method, which has been proven to be a more consistent and time-saving methodologies in empirical research. In this context, the study has the following objectives:

1. To identify and analyze the criteria of green enablers in the context of environmentally sustainable Indian airports
2. To evaluate and select the best airports based on green practices.

The rest of the paper is structured as follows: Section two deals with literature review on the selection of criteria for green evaluation of airports and theoretical underpinnings for finalizing these criteria. Section three explains the hybrid methodology employed in this paper. Section four presents the case analysis of five airports using the proposed methodology. Section five is dedicated to perform sensitivity analysis for checking the robustness of the model. Section six discusses the results obtained through analysis, and the last section presents the conclusions, implications, and scope of future work.

2. Literature review

2.1. Theoretical underpinnings

Literature review suggests that a single theory is not sufficient to discuss the issue relating to the adoption of green practices in the aviation industry. For example, the application of multiple organizational theories has been witnessed by various researchers in the emerging green supply chain management (GSCM), green innovations (GI), green information technology (GIT), social responsibility, and environmentally sustainable activities (Khor, Thurasamy, Ahmad, Halim, & May-Chiun, 2015; Kumar & Dixit, 2018a; Sarkis, Zhu, & Lai, 2011; Somsuk & Laosirihongthong, 2017; Wong & Fryxell, 2004; Zhu, Geng, Sarkis, & Lai, 2011; 2012). However, there is still lack of theoretical research related to green airport management in India. Though numerous studies rely on some theories to explain the sustainable management practices in the aviation industry, they have single-handedly focused on a particular theory to explain the problem (Chao, Lirn, & Lin, 2017; Nair & Paulose, 2014; Santos, Rodrigues, & Branco, 2016; Sinha, Whitman, & Malzahn, 2004; Upham & Mills, 2005; Uysal & Sogut, 2017; Vejvar, Lai, Lo, & Fürst, 2017). Considering the given complexity depending on the multiple factors, a framework using multiple theories is proposed, which may be helpful in providing some fruitful insights into the adoption of green practices in the airport. Finally, we have considered four theories such as the resource-based view (RBV), institutional theory (INT), stakeholder theory (ST), and ecological modernization theory (EMT) as the theoretical underpinnings in our study. Table 1 depicts the theoretical rationale of the green practices behind adopting the green airport.

2.1.1. Resource-based view (RBV)

The resource-based view (RBV) approach provides a theoretical understanding about firms ability to achieve competitive advantage by identifying their own key resources that are exceptional and core competencies for sustaining in the marketplace (Acedo, Barroso, & Galan, 2006; Agoi, 2013; Barney, 1991; Finney, Lueg, & Campbell, 2008; Sarkis et al., 2011). Based on the perspective of RBV theory, the top stakeholders need to have the knowledge of green practices for compeling transformational activities in the reinvention of the business strategies (Kearns & Sabherwal, 2006).

2.1.2. Institutional theory (INT)

Institutional theory (INT) provides a theoretical understanding, which can be used to examine how organizations will be strongly influenced by institutional norms and global environmental regulatory pressure for adopting green practices in their entire supply chain (DiMaggio & Powell, 1983; Delmas & Toffel, 2004; Hirsch, 1975; Kilbourne, Beckmann, & Thelen, 2002; Kumar & Dixit, 2018a; Zailani, Govindan, Iranmanesh, Shaharudin, & Chong, 2015). According to Lynes and Dredge (2006), employee skills and productivity can be enhanced through participation of an organization in green initiatives. The suitability of Institutional theory is quite useful for analyzing the green practice in the aviation industry (Bartle, 2006; Brombal, Moriggi, & Marcomini, 2017; Jongsaguan & Ghoneim, 2017; Kearins & Fryer, 2011; Lagat, 2013; Tiwari, 2005).

2.1.3. Stakeholder theory (ST)

Stakeholder theory is one of the important theories of organizational management, which provides a theoretical understanding to analyze the antecedent of adopting environmental or green practices in aviation industry like green human resource management (GHRM), green innovation (GI), waste minimization, and recycling management (Amaeshi & Crane, 2006; Freeman, 1983; Kumar & Dixit, 2018a;

Table 1
Theoretical basis for finalizing the green performance criteria.

Theory	Basics of the theory	Main criteria	Sub-criteria
Resource Based View (RBV)	Resource-based view theory states that the organizations are comprised of an array of resources and technological competencies that provides the platform for their firms to achieve competitive advantage globally	*Green building and infrastructure*	Green building design and Retrofitted practices Infrastructural harmonization with the environment Biodiverse seating lounge for travelers Solar Energy storage capacity facilities
		Air and noise control	Indoor Environmental Quality Monitoring and communication of noise level data
		Environmental and monitoring control	Carbon footprint method for airport management Greenhouse gas (GHG) inventory database system Geographical location of the airports
		Green operation and transportation	Low emission ground logistics vehicles Green cargo hub for logistics activities Use of lightweight aircraft
Institutional theory (INT)	The institutional theory provides a theoretical platform to analyze the legitimacy of environmentally sustainable practices such as global environmental regulations and policies	*Air and noise control*	Reduction of harmful pollutant Emission and mitigation practices
		Environmental and monitoring control	ISO certification for environment and energy management Reduction of Greenhouse gas (GHG) emissions Initiatives for clean development mechanism (CDM) projects Green practices for thermal management and climate change
		Green policies and regulation	Airport carbon accreditation by the ACI (airport council international) Policies and regulations for green airport spaces to be structured in a supportive manner Enable financial regulatory framework for low carbon and climate change (LCR) infrastructure Promote eco-tourism policies Compliance with global environmental laws and regulation
		Waste management and recycling Practices	Reduction in community landfills due to solid waste ashes used for construction material Ecological conservation Safe disposal of hazardous waste
		Employee green training	Educational Seminars for Energy conservation Creating a friendly and safe work environment Knowledge transfer (KT)
Stakeholders theory (ST)	Stakeholder theory defines that one stakeholder must relate or coordinate with other stakeholders within the entire supply chain activities to achieve a competitive advantage in the business	*Green operation and transportation*	The green share of public transport
		Green policies and regulation	Local community consultation for airport masterplan
		Employee green training	Functional green teams Reinforcing employee capabilities and attitude via professional training
Ecological modernization theory (EMT)	Ecological modernization theory defines that an organization should explore the innovative practices to improve the environmental sustainability in the supply chain	*Green building and infrastructure*	The eco-efficient airport parking area Energy saving techniques Energy efficient materials for building construction
		Air and Noise control	Noise abatement techniques
		Waste management and recycling Practices	Wastewater harvesting Use of cleaner technologies for recycling In-house production of waste to energy (WTE)
		Green operation and transportation	Use of alternative biofuels in aircraft Alliance with green partners
		Employee green training	Paperless work environment

Upham & Mills, 2005). The stakeholder theory states that stakeholder must develop alliance or coordination with another stakeholder within the entire supply chain activities to achieve sustainable advantage (Bjerkan, Sund, & Nordtømme, 2014). Numerous studies have analyzed the role of stakeholders in influencing the adoption of environmentally responsible business practices in the aviation industry (Sarkis et al., 2011; Vachon & Klassen, 2008; Wong & Fryxell, 2004; Yang & Rivers, 2009; Zailani et al., 2015).

2.1.4. Ecological modernization theory (EMT)

Ecological modernization theory (EMT) provides a theoretical lens to understand the dynamics in environmental policies and regulation of sustainable production and consumption activities (Choy, 2007). EMT emphasizes the need of upgraded technology, green innovation, and cleaner technologies for waste reduction, resource recovery, and remanufacturing practices toward achieving environmental sustainability while cultivating economic benefits (Jänicke, 2008; Mol & Sonnenfeld, 2000; Pataki, 2005). Various researchers have analyzed the application of EMT in the context of the airline industry (Bruce & Spinardi, 2018; Griggs & Howarth, 2013; Jian, 2012; Walker & Cook, 2009; Welford, Hills, & Lam, 2006).

2.2. Review of past studies and green performance criteria

The categorization of the airport as a "Green Airport" in an ecological sense was a recognition of the airport in its dedication to a higher level of environmental protection and responsibility to the local community, but it was also used as the basis of a successful marketing promotion (Štimac, Sente, & Zibar, 2017). Aviation is a critical part of any economy, thereby providing for the movement of people and goods throughout the world by enabling economic growth (Waitz, Townsend, Cutcher-Gershenfeld, Greitzer, & Kerrebrock, 2004). The Directorate General of Civil Aviation (DGCA) has issued many guidelines addressing various concerns like fuel efficiency, data reporting, power supply, etc., in the Indian aviation sector. However, significant challenges like lack of technology adoption, use of biofuels, etc., remain a concern for the industry (DGCA Report, 2013). The development of green and sustainable airports is the future of airport planning considering its impact on the environment and residents (Chao et al., 2017).

In accordance with the development of green and sustainable airports, we would discuss some important studies related to the literature on green aviation. Gasco et al. (2017) compiled the literature on communication of noise data from aircraft and variety of indicators to communicate it with public. Technology has enabled communication to public to be hassle-free, but the lack of standardization, complexity of the reported data, etc., remain as a challenge. Uysal and Sogut (2017) studied Enterprise Architecture (EA) based energy management in Istanbul Airport, Turkey, and found a potential 70% energy savings efficiency of terminal buildings through sustainable practices. The research concludes by proposing a holistic and integrated approach to energy management in airports. Grampella, Martini, Scotti, Tassan, and Zambon (2017) investigated the factors affecting the annual environmental effects produced by national aviation system. The study collected the data set on 31 Italian airports during the period 1999–2008 and found 1.05% increase in environmental effects with a 1% increase in airport's yearly movements. Chao et al. (2017) developed an evaluation model for analyzing environmental protection performance of airports using the Fuzzy Delphi method. Of the 16 indicators, they found the 'energy-saving control,' 'easy airport access by public transport,' and 'aircraft carbon management as the top three indicators. Ferrulli (2016) focused on the project compliance with green building requirements during the preliminary stages of project design and found that the environmental issues related with the current operation of the airport can restrict future growth potential. Moreover, researchers have proposed a GrADE methodological framework to measure and monitor environmental sustainability performance. Kılkış and Kılkış (2016) developed and applied the sustainability ranking index with five dimensions and 25 indicators to airports. The dimensions were airport services and quality, energy consumption and generation, carbon dioxide emissions and mitigation planning, environmental management and biodiversity, and atmosphere and low emission transport. The index was based on a sample of nine best and busiest airports in the world based on passenger traffic and satisfaction. Amsterdam Schiphol, Frankfurt, Munich, Istanbul Atatürk, and London Heathrow airports are the top five airports in the sample. Wu, Cheng, and Ai (2017) explored the green switching intentions of 615 airline passengers based on the eco-friendly services of China Airlines. Research has found 'green perceived value' as the most influential factor in green experiential satisfaction. The physical environmental quality and green corporate image have also been found to be significant in the analysis. Štimac et al. (2017) explored the problems of the airline industry related to the environment and increased air traffic and suggested the Collaborative Environmental Management (CEM) approach to build green airports. The case study emphasizes on the significance of controlling noise pollution owing to increased air traffic and other vehicles. Study further found that the regulatory measures with technological sophistication have improved ecological balance. Skouloudis, Evangelinos, and Moraitis (2012) assessed the quality and comprehensiveness of Corporate Social Responsibility reports published by the international airports. The findings shed light on the fact that CSR reporting is not a common practice among international airports, and the analyzed reports found variation in the disclosure practices. Lee, Tsai, Yang, and Lin (2018) proposed a Multi-Criteria Decision making (MCDM) approach with DEMATEL, ANP, and Zero-one goal programming to make optimal strategic decisions related to green aviation fleet management. The study found the emission trading programme as the major factor for meeting green fleet goals. Upham et al. (2003) studied the environmental factors that influence airport growth. The study observed that environmental function of the airport based on infrastructure particularly hinders the growth of airports and suggested that the limited environmental capacity of the airports signifies the need for collective determination and negotiation. Freestone, Baker, and Stevens (2011) focused more on the environmental planning and regulations related to the development of the airport land in Australia and criticized the reluctance of the government in implementing radical strategies in the interests of the various political, community, and private sector stakeholders. Rezaee and Yousefi (2018) examined the Urmia international airport and found that 'Lack of staff training', 'inappropriate ground handling' and 'inoperable navigation aid' are critical risk factors. They analyzed and prioritized airports risks and their impact on the system using Fuzzy cognitive map (FCM) method and Slack based data envelopment method (SBDEA). Baxter, Srisaeng, and Wild (2018) carried out an in-depth case study analysis at the Kansai International Airport from 2002 to 2015 to examine the waste management practices of the airport. They employed quantitative analysis using t-tests and found a statistically significant reduction in waste per passenger and aircraft movement along with significant increase in the waste recycled. The study recommended that the success of the Kansai airport must be followed by other airport across the world to improve sustainability. With the help of further extensive literature review, researchers have identified different enablers for green airport implementation and classified it under seven categories as shown below.

2.2.1. Air and noise control

The aviation industry is one of the significant contributors to air pollution and global warming (Uysal & Sogut, 2017). The issue of airport air quality and noise control has further shifted to climate change and global warming (EEA, 2007; EEA, 2012; Thomas et al., 2010). However, the issues related to noise and air quality remain a challenge for airport authorities across the world (Gasco et al., 2017). Global airport activities have released 35 million tons of CO_2 in 2013, which is 5% of the total CO_2 emission by the entire aviation sector. The share of Indian airports stood at 0.78 million tons in the same year (DGCA, 2013). Therefore, noise pollution is one of the major reasons for public complaints in airports (Havelock & Turner, 2007). The framing of operating restrictions along with the quietest operating procedures can be effectively implemented to tap this problem (Girvin, 2009; Licitra & Ascari, 2014; Netjasov, 2012, 2016; Vogiatzis, 2012).

Many Indian airports including IG airport Delhi have been converted in to 'Silent airports' by prohibiting announcements inside the terminal to reduce maximum noise in the airport premises. Though such practices reduce noise in the airports, there is no substantial increase in acceptance from citizens (Babisch et al., 2009; Brooker, 2009).

2.2.2. Green building and infrastructure

The major challenge for airport growth is the development of infrastructure design by integrating urban planning. The design of the airport by accommodating environmental concerns and traffic capacity is really challenging because of the functional and surrounding facilities (Ferrulli, 2016). Nevertheless, the energy saving capacity of airport buildings to a potential of 70% of the total airport energy consumption signifies the importance of green buildings and infrastructure (Olgyay & Herdt, 2004; Uysal & Sogut, 2017). Balaras et al. (2003) in their study on Greek airports found 35% energy potential related to thermal loads, which further support this criterion. Airports must be developed in a way that the operational capacity and future development is not affected by the environmental constraints (Thomas, Hooper, Mumayiz, & Wright, 2011; Thomas et al., 2010; Thomas et al., 2011). This can be achieved with the proper balance between social and economic objectives within the limits imposed by the government (Upham et al., 2003). Green design—an approach to product design with zero or minimal waste generation—also has a significant role in this (Roy, 2000). Along with the focus on buildings and infrastructure, the use of renewable energy sources and energy saving techniques has also become a critical factor in energy management of airports (Uysal & Sogut, 2017). Furthermore, airport authorities can frame green building practices to make airport buildings greener and eco-friendly (Chang & Yeh, 2016).

2.2.3. Waste management and recycling practices

Waste management in airports is one of the critical environmental issues that are faced by airports globally (Baxter et al., 2018). Solid and hazardous waste generated by airports can be mainly processed in three ways: (1) Recycling, (2) Incineration, and (3) Disposal to landfill. Innovation has made business to treat waste as a resource for optimizing the best use of resources and reducing the negative impact on the environment. The waste hierarchy approach focuses on waste prevention, which is a crucial pillar of green economy that helps in improving resource efficiency and reducing the need for raw materials. The waste hierarchy begins with prevention and moves on to reuse, recycle, recovery, and finally disposal (Kumar, Dixit, & Prabhakar, 2016). The main intention of airports regarding environmental practices is cutting resource utilization and waste generation (Cairncross, 1995; Gilley, Worrell, & El-Jelly, 2000), which is followed by the positive image in the society (Fineman, 1997; Font, 2001; Khanna & Anton, 2002). Ground handling operations can also influence environmental challenges through recycling, waste management, and community partnership programs (ICAO, 2016). Wastewater harvesting is a common practice in many airports across the world to reuse the wastewater for toiletries and gardening.

2.2.4. Environmental monitoring and control

Postorino and Mantecchini (2014) developed and applied a carbon footprint method for land vehicles, airport handling, and terminal equipment at Bologna Airport. The Directorate General of Civil Aviation (DGCA) India has published its first carbon footprint report in 2012, which has reported that the total CO_2 emission is 15, 389, 000 tonnes; hence, it is alarming for a developing nation like India (DGCA, 2012). CO_2 emissions can significantly affect the energy efficiency of airports (Balaras et al., 2003). Hence, the reduction of CO_2 emission is a primary concern for the aviation sector (Cui, Li, Yu, & Wei, 2016; Dray, Evans, Reynolds, & Schäfer, 2010). Along with the rising CO_2 emissions in the aviation sector, the greenhouse gas emission is also a critical issue. Renewable energy sources can be effectively used to reduce greenhouse gas emissions by the airports. Indian airports like Cochin, Delhi, Mumbai, and Chandigarh have already installed solar power plants as a step toward renewable and non-polluting energy sources for airport operations. However, despite the common belief, energy management has become more challenging for airports owing to the availability of various energy sources and technologies (Dijkema, van der Zee, Brunekreef, & van Strien, 2008; Uysal & Sogut, 2017). The geographical location of the airports can influence the ability of the airports in adopting environmental and monitoring control techniques. Power, fuel, and water consumption of airports can vary according to the geographical location of the airports (Pitt & Smith, 2003).

2.2.5. Green operation and transportation

The transportation system in the airport from aircraft to ground duty vehicles can do a lot in the green aviation practices of airports. The practices associated with the use of biofuels for aircraft as well as for ground duty vehicles are increasing in the present context (Abdullah, Chew, & Hamid, 2016; Björklund, 2011; Chang & Yeh, 2016). The reduction in commercial vehicle trips and use of electric vehicles are becoming common practices in airports to achieve sustainability (Kılkış & Kılkış, 2016; Nair & Paulose, 2014; Postorino & Mantecchini, 2014). Bus services from Aero city metro to Delhi airport, bus services to Hyderabad airport, etc., are examples from India which can lead to sustainable and green civil aviation in India.

2.2.6. Employee green training

Educating employees on the importance of green practices in the airport through seminars and workshops are effective measures, which can be taken to achieve green practices in the aviation industry (Chang & Yeh, 2016; Teixeira, Jabbour, de Sousa Jabbour, Latan, & de Oliveira, 2016). Employees' capability can be further enhanced through professional training by providing them a healthy and safe work environment (Chang & Yeh, 2016; Ellinger & Ellinger, 2014). Knowledge transfer (KT) of environmental management experiences assist management to implement green practices more effectively (Jabbour, 2011).

2.2.7. Green policies and regulations

Environmental management practices in airports are also motivated to avoid regulatory actions. The increase in energy costs and green mandates by the local directives are the other driving force (Uysal & Sogut, 2017). The adherence to such regulations can bring greater benefits such as higher productivity, optimum asset utilization, etc. (Pauwels & van Hoeve, 2010). Regulatory intervention by the authorities are found to have great impact on regulating transportation industry (Corfee-Morlot et al., 2012; Graham, 2005; Lee et al., 2018; Lynes & Dredge, 2006; Sarkar, 2012).

2.3. Research gaps and highlights

Studies on green aviation has been primarily focused on the developed nations (Gasco et al., 2017; Grampella et al., 2017; Skouloudis et al., 2012; Upham et al., 2003) and less on the developing nations (Lee et al., 2018; Wu et al., 2017). The issues relating to the sustainability of specific industrial sectors such as aviation are relatively under-researched (Upham et al., 2003). However, airports are currently designed with efficiency and considered economic growth as priorities (Boons, Van Buuren, & Teisman, 2010). This can have a significant difference in the enablers for green airport development between developing nation and developed nation on the basis of availability of resources, skilled manpower, government policies, etc. Moreover, the aviation rules and policies can vary from country to country (Grampella et al., 2017). Nevertheless, there is a dearth of studies in the Indian context on enablers for green airports. India is one of the largest emerging economies in Asia with hundreds of airports and 170 million passengers per annum on an average (DGCA, 2013).

Further, studies on green airports have extensively applied the case study approach (Baxter et al., 2018; Giustozzi, Toraldo, & Crispino, 2012; Monsalud, Ho, & Rakas, 2015) or theoretical frameworks (Freestone et al., 2011; Upham et al., 2003; Štimac et al., 2017) or traditional statistical tools (Grampella et al., 2017; Wu et al., 2017). Though few studies have employed MCDM techniques such as AHP (Chao et al., 2017) or DEMATEL (Lee et al., 2018), research seems to emphasize only on few enablers of green airport development such as air and noise control (Barrett, Britter, & Waitz, 2013; Chang & Yeh, 2016; Gasco et al., 2017), energy management (Graham, 2005; Chang & Yeh, 2016; Uysal & Sogut, 2017; Kılkış & Kılkış, 2016), low emission transportation (Chang & Yeh, 2016; Postorino & Mantecchini, 2014). However, they have given less emphasis on green training (Mandip, 2012), green policies and regulations (Miller, 2001), waste management and recycling, and environmental monitoring and control practices (Postorino & Mantecchini, 2014; Uysal & Sogut, 2017). It is evident from the recent literature that majority of studies lack theoretical underpinnings on aviation sector (Chao et al., 2017; Ferrulli, 2016; Grampella et al., 2017; Lee et al., 2018; Skouloudis et al., 2012; Štimac et al., 2017).

Therefore, these gaps are bridged by conducting this study in the context of a developing nation like India and employing a novel and advanced hybrid MCDM technique of BWM and VIKOR for analyzing 43 criteria under sevencategories with the support of four organizational theories.

Table 1 presents the theoretical foundation for finalizing the criteria and Table 2 presents the finalized criteria grouped into seven main categories.

3. Research methodology

A three-phase methodology has been used in this study to evaluate the green performance of the airports (see Fig. 1). The objective of using this three-phase methodology is to primarily finalize the criteria for evaluation of the green performance of airports through literature review and expert opinion and subsequently through evaluation of the performance of selected airports using quantitative analysis. The first phase identifies the evaluation criteria through extensive literature review and then finalization of these criteria through a panel discussion with experts. The second phase provides ranking of the evaluation criteria for green performance of airports by employing BWM, and the third phase evaluates the performance of selected airports on these criteria using VIKOR methodology.

Various phases are explained below:

3.1. Finalization of green evaluation criteria and obtaining weights of green evaluation practices using BWM

Literature review, Delphi method, and panel discussion with experts have been used to finalize the criteria for green evaluation of the airports. BWM is a very strong MCDM technique and is widely used by different researchers. For instance, Gupta and Barua (2016b) used it for technological innovation enablers ranking; Rezaei, Nispeling, Sarkis, and Tavasszy (2016) for green supplier selection; Gupta and Barua (2017) for green supplier selection; Gupta (2018a) for airport evaluation based on service quality; Salimi and Rezaei (2018) for evaluating firms RND performance; van de Kaa, Kamp, and Rezaei (2017a, 2017b) for the selection of biomass technology and electric vehicle, respectively; Abadi, Sahebi, Arab, Alavi, and Karachi (2018) for the evaluation of medical tourism strategy; Gupta (2018b) for Green Human Resource Management; and Rezaei, Kothadiya, Tavasszy, and Kroesen (2018) for quality assessment of airport baggage handling. The steps as given by Rezaei (2016a; 2016b) are explained below:

Step 1: Selection of attributes for analysis through literature review and expert opinion.

Step 2: Among the finalized attributes, the best and the worst attributes were finalized by each expert from both the main as well as sub category attributes.

Step 3: Each expert was asked to give a preference rating for the best attribute selected over all other attributes using a scale of 1–9.

Step 4: The experts provided the preference rating of all attributes with regard to the worst attribute.

Step 5: The optimized weights (w_1^*, w_2^*, … …. , w_n^*) for all the attributes was calculated.

The objective of the study is to obtain the weights of attributes so that the maximum absolute differences for all j can be minimized for $\{|w_B - a_{Bj}w_j|,\ |w_j - a_{jW}w_W|\}$. The following minimax model will be obtained:

$$\min \max \{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\}$$
$$\text{s.t.} \sum_j w_j = 1$$
$$w_j \geq 0,\ for\ all\ j \tag{1}$$

Model (1) upon transformed into a linear model gives better results, the model is shown below:

$$\min \xi^L$$
s.t.
$$|w_B - a_{Bj}w_j| \leq \xi^L, \text{ for all j}$$
$$|w_j - a_{jW}w_W| \leq \xi^L, \text{ for all j}$$
$$\sum_j w_j = 1$$

$w_j \geq 0$, for all j (2).

Model (2) can be solved to obtain optimal weights (w_1^*, w_2^*,… …. , w_n^*) and optimal valueξ^L.

Consistency (ξ^L) of attribute comparisons close to 0 is desired (Rezaei, 2016a, 2016b).

3.2. Ranking the alternatives using VIKOR

The steps of VIKOR methodology are discussed below:

Step 1: It was vital to obtain a pairwise matrix of criteria and alternatives using scale mentioned in Table 3.

Step 2: Using equation (3), the average decision matrix was obtained.

$$F = \frac{1}{k}\sum_{k=1}^{k} F_k \tag{3}$$

where, F is average decision matrix and k is the number of decision makers

Step 3: Using equations (4) and (5), the best $f_b^*$and the worst f_b^-values of all the criteria, b = 1, 2, ….n were obtained.

$$f_b^* = Max\ (f_{ab}) \tag{4}$$

$$f_b^- = Min\ (f_{ab}) \tag{5}$$

where, $f_b^*$is the positive ideal solution and $f_b^-$is the negative ideal solution for the b_{th} attribute.

Step 4: Compute the S_a and R_a values for a = 1, 2, … …. m using equations (6) and (7).

$$S_a = \sum_{b=1}^{n} W_b\,[(f_b^* - f_{ab})/(f_b^* - f_b^-)] \tag{6}$$

$$R_a = Max_b\ [W_b\,(f_b^* - f_{ab})/(f_b^* - f_b^-)] \tag{7}$$

where, solution given by $S_a$and $R_a$are based on the value maximum group utility (majority rule) and minimum individual regret of the opponent respectively, and $W_b$represents the weights of the criteria (Ebrahimnejad, Mousavi, Tavakkoli-Moghaddam, & Heydar, 2012).

Step 5: Using equation (8), the scores for Q_a were computed.

$$Q_a = v\left(\frac{S_a - S^*}{S^- - S^*}\right) + (1 - v)\left(\frac{R_a - R^*}{R^- - R^*}\right) \tag{8}$$

where,
$S^- = Max_a S_a,\ \ S^* = Min_a S_a,\ \ R^- = Max_a R_a,\ \ R^* = Min_a R_a\ and\ v$denotes the weight of the strategy of "the majority of criteria" (or the maximum group utility), here $v = 0.5$. This compromise solution is stable within a

Table 2
Finalized criteria for evaluating the green performance of the airports.

Main criteria	Code	Sub criteria	Explanation
Air and Noise Control (ANC)	ANC1	Indoor Environmental Quality	Environmental issues related to aircraft noise, emissions from the airport vehicles etc.
	ANC2	Reduction of harmful pollutant	
	ANC3	Monitoring and communication of noise level data	
	ANC4	Emission and mitigation practices	
	ANC5	Noise abatement techniques	
Green building and infrastructure (GBI)	GBI1	Green building design and Retrofitted practices	A strategic and integrated approach to define the airport infrastructure design complying with the specific sustainability requirements.
	GBI2	Energy saving techniques	
	GBI3	The eco-efficient airport parking area	
	GBI4	Energy efficient materials for building construction	
	GBI5	Infrastructural harmonization with the environment	
	GBI6	Biodiverse seating lounge for travelers	
	GBI7	Solar Energy storage capacity facilities	
Waste management and recycling Practices (WRP)	WRP1	Wastewater harvesting	The process of managing airport wastes from its inception to its disposal and offers a variety of solutions for recycling items that don't belong to trash.
	WRP2	Use of cleaner technologies for recycling	
	WRP3	In-house production of waste to energy (WTE)	
	WRP4	Reduction in community landfills due to solid waste ashes used for construction material	
	WRP5	Ecological conservation	
	WRP6	Safe disposal of hazardous waste	
Environmental monitoring and control (EMC)	EMC1	ISO certification for environment and energy management	The broad range of activities including detection of a variety of gases. Monitoring implies continuous vigilant oversight of the status of these areas.
	EMC2	Reduction of Greenhouse gas (GHG) emissions	
	EMC3	Carbon footprint method for airport management	
	EMC4	Greenhouse gas (GHG) inventory database system	
	EMC5	Initiatives for clean development mechanism (CDM) projects	
	EMC6	Green practices for thermal management and climate change	
	EMC7	Geographical location of the airports	
Green operation and transportation (GOT)	GOT1	Use of alternative biofuels in aircraft	Transportation service which has a lesser or reduced negative impact on human health and the natural environment when compared with competing for transportation services that serve the same purpose
	GOT2	The green share of public transport	
	GOT3	Low emission ground logistics vehicles	
	GOT4	Green cargo hub for logistics activities	
	GOT5	Alliance with green partners	
	GOT6	Use of lightweight aircraft	
Employee green training (EGT)	EGT1	Educational Seminars for Energy conservation	Organizational learning and the alignment of human resources practices to the greening of airports.
	EGT2	Reinforcing employee capabilities and attitude via professional training	
	EGT3	Creating a friendly and safe work environment	
	EGT4	Paperless work environment	
	EGT5	Functional green teams	
	EGT6	Knowledge transfer (KT) of environmental management experiences	
Green policies and regulations (GPR)	GPR1	Compliance with global environmental laws and regulation	The commitment of the airport to the laws, regulations, and other national and international policies.
	GPR2	Airport carbon accreditation by the ACI (airport council international)	
	GPR3	Enable financial regulatory framework for low carbon and climate change (LCR) infrastructure	
	GPR4	Promote eco-tourism policies	
	GPR5	Local community consultation for airport masterplan	
	GPR6	Policies and regulations for green airport spaces to be structured in a supportive manner	

decision making process, which could be: “voting by majority rule” (when $v > 0.5$ is needed), or “by consensus” $v = 0.5$, or “with veto” ($v < 0:5$) (Chang, 2014; Ebrahimnejad et al., 2012; Gupta, 2018a; Liu, Liu, Liu, & Mao, 2012; Opricovic & Tzeng, 2004; Sanayei, Mousavi, & Yazdankhah, 2010; Sayadi, Heydari, & Shahanaghi, 2009). Qa denotes VIKOR index.

Step 6: Using $Q_a$values, the alternatives were ranked.

Step 7: The alternatives were ranked based on the minimum $Q_a$values obtained in accordance with the simultaneously satisfying two conditions:

Condition 1. Q(A(1)) is chosen if Q(A(2)) – Q(A(1)) ≥ 1/n-1, where A(2) is the alternative that has got the second rank in the analysis and n is the total alternatives.

Condition 2. Q(A(1)) also obtains the first rank according to both $S_a$and $R_a$values.

Step 8: Alternatively, the obtained minimum score in Q_a is ranked first.

4. Case analysis and application using proposed methodology

For the purpose of evaluating the green performance of the airports,

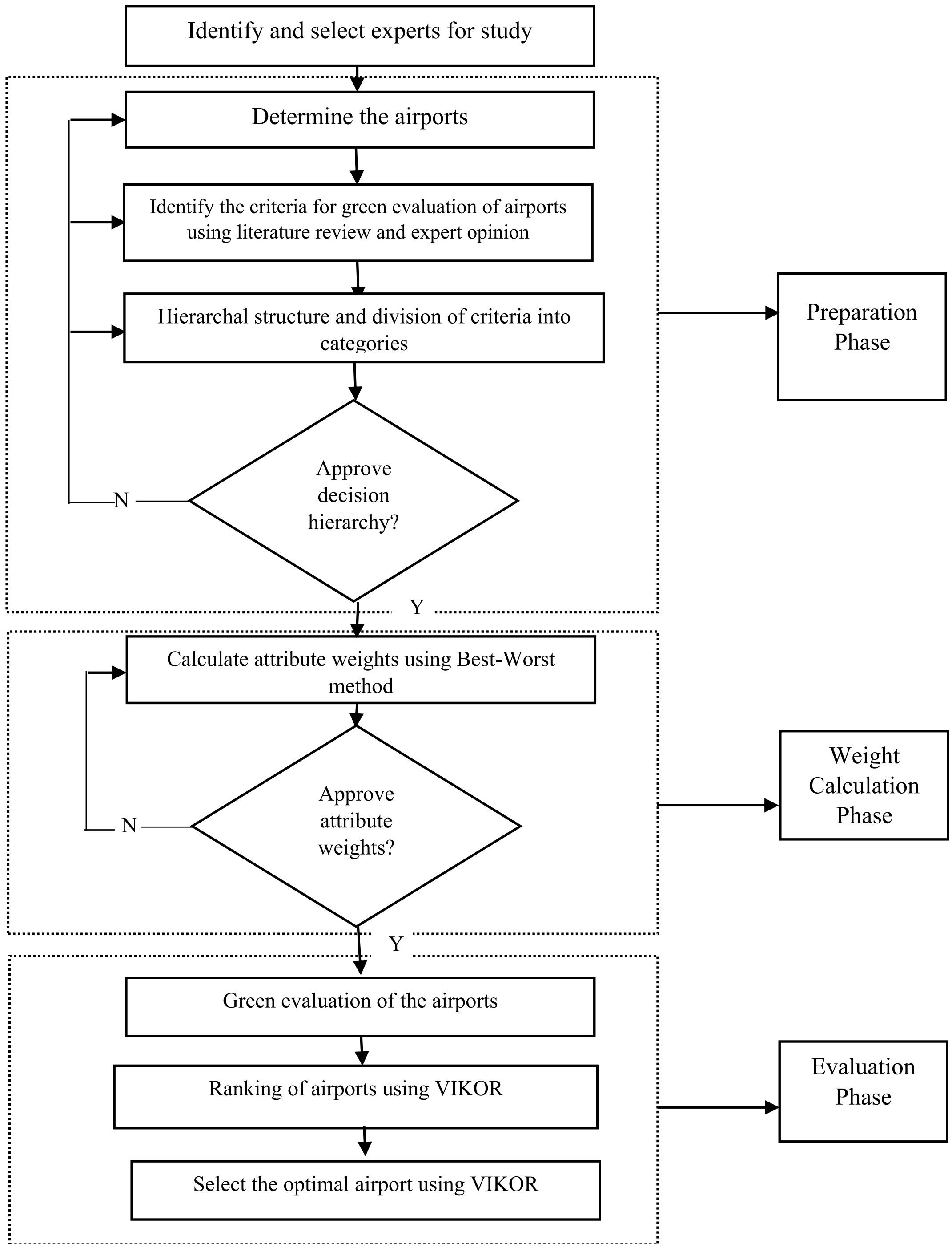

Fig. 1. Schematic diagram for phases of methodology.

Table 3
Linguistic scale for pairwise comparison for VIKOR methodology.

Scale for VIKOR methodology	
Linguistic variables	Importance rating
Least Important	1
Moderately Important	2
Strongly Important	3
Very Strongly Important	4
Extremely Important	5

five Indian airports having both the domestic and international operations were selected. The proposed methodology was applied to evaluate the green performance of these airports based on the finalized criteria. For finalization of the evaluation criteria and rating of these criteria, a panel of four experts was formed; these experts also evaluated these criteria with respect to their finalized criteria. Expert 1 is a general manager of Airport Transport Management (ATM) and has working experience of more than 20 years. Expert 2 being DGM of Environmental Quality Management System (EMQS) is working in the field of airport environmental management for more than 15 years.

Table 4
Best and Worst green evaluation criteria identified by experts.

Green evaluation criteria for airport evaluation	Determined as Best by experts	Determined as Worst by experts
Air and Noise Control (ANC)		
ANC1	2, 4	
ANC2	1, 3	
ANC3		1, 2, 3
ANC4		
ANC5		4
Green Building and Infrastructure (GBI)	**3**	
GBI1	1, 3, 4	
GBI2		
GBI3		2, 3
GBI4	2	
GBI5		
GBI6		1, 4
GBI7		
Waste management and Recycling Practices (WRP)		
WRP1	3	
WRP2		
WRP3		
WRP4		1, 2
WRP5		3, 4
WRP6	1, 2, 4	
Environmental Monitoring and Control (EMC)		
EMC1		
EMC2	2, 4	
EMC3		
EMC4		1, 2, 3, 4
EMC5		
EMC6	1, 3	
EMC7		
Green Operation and Transportation (GOT)		
GOT1		
GOT2		
GOT3	1, 2, 4	
GOT4	3	
GOT5		1, 3
GOT6		2, 4
Employee Green Training (EGT)		**1, 2, 3, 4**
EGT1		
EGT2	1, 3, 4	
EGT3		1, 2, 3, 4
EGT4		
EGT5	2	
EGT6		
Green Policies and Regulations (GPR)	**1, 2, 4**	
GPR1		
GPR2	1, 2	
GPR3	3, 4	
GPR4		1, 2, 4
GPR5		3
GPR6		

Expert 3 is a DGM of Legal department and has experience of handling legal issues related to airport development and land acquisition for more than 15 years. Expert 4 being DGM of Aerodrome Planning and Architecture is working in the field of airport planning and infrastructure development for more than 15 years.

4.1. Finalization of green evaluation criteria

The extensive literature review and the Delphi method were used to finalize the criteria for green evaluation of the airports. After a detailed literature review, thirty-nine criteria were identified and were presented to experts for finalization of criteria. After several rounds of deliberations and discussion with experts, three criteria were deleted and seven new criteria as suggested by experts were added, thus taking

Table 5
Main category criteria comparison.

BO	Air and Noise Control (ANC)	Green Building and Infrastructure (GBI)	Waste management and Recycling Practices (WRP)	Environmental Monitoring and Control (EMC)	Green Operation and Transportation (GOT)	Employee Green Training (EGT)	Green Policies and Regulations (GPR)
Best criteria: Green Policies and Regulations (GPR)	7	2	6	4	5	9	1

OW	Worst criteria: **Employee Green Training (EGT)**
Air and Noise Control (ANC)	2
Green Building and Infrastructure (GBI)	5
Waste management and Recycling Practices (WRP)	3
Environmental Monitoring and Control (EMC)	4
Green Operation and Transportation (GOT)	2
Employee Green Training (EGT)	1
Green Policies and Regulations (GPR)	9

Table 6
Aggregate weights of Main and sub-criteria for all the experts.

Main Criteria	Weights of Main Criteria	Sub Criteria	Weights of Sub Criteria	Global Weights	Ranking
Air and Noise Control (ANC)	0.122	ANC1	0.336	0.041	9
		ANC2	0.358	0.044	7
		ANC3	0.059	0.007	32
		ANC4	0.156	0.019	19
		ANC5	0.091	0.011	27
Green Building and Infrastructure (GBI)	0.226	GBI1	0.312	0.070	3
		GBI2	0.159	0.036	10
		GBI3	0.051	0.011	26
		GBI4	0.220	0.050	5
		GBI5	0.090	0.020	17
		GBI6	0.046	0.010	28
		GBI7	0.107	0.024	13
Waste management and Recycling Practices (WRP)	0.077	WRP1	0.197	0.015	21
		WRP2	0.187	0.014	22
		WRP3	0.136	0.010	29
		WRP4	0.055	0.004	39
		WRP5	0.059	0.005	38
		WRP6	0.366	0.028	12
Environmental Monitoring and Control (EMC)	0.085	EMC1	0.149	0.013	24
		EMC2	0.283	0.024	14
		EMC3	0.079	0.007	34
		EMC4	0.037	0.003	42
		EMC5	0.076	0.006	36
		EMC6	0.260	0.022	15
		EMC7	0.107	0.009	31
Green Operation and Transportation (GOT)	0.116	GOT1	0.103	0.012	25
		GOT2	0.169	0.020	18
		GOT3	0.369	0.043	8
		GOT4	0.243	0.028	11
		GOT5	0.056	0.007	35
		GOT6	0.059	0.007	33
Employee Green Training (EGT)	0.039	EGT1	0.100	0.004	40
		EGT2	0.371	0.014	23
		EGT3	0.044	0.002	43
		EGT4	0.134	0.005	37
		EGT5	0.257	0.010	30
		EGT6	0.094	0.004	41
Green Policies and Regulations (GPR)	0.335	GPR1	0.156	0.052	4
		GPR2	0.287	0.096	2
		GPR3	0.306	0.102	1
		GPR4	0.048	0.016	20
		GPR5	0.065	0.022	16
		GPR6	0.138	0.046	6

the total criteria to forty-three. These criteria were then categorized into seven main categories for the purpose of evaluation and ranking.

4.2. Attributes weights calculation using the best-worst method

After finalizing the criteria for green evaluation of airports, the weights of the criteria were calculated using BWM. Four experts were asked to identify the best and worst criteria among the main category criteria as well as subcategory criteria. The best and worst criteria identified by different experts are shown in Table 4 below.

After obtaining the best and worst criteria by each expert, all the experts were asked to give preference rating of the best criteria compared to the other criteria, and the other criteria compared to the worst criteria for main category criteria as well as subcategory criteria. The preference rating obtained by expert 1 for main category criteria was shown in Table 5 below.

As the ratings of all the main criteria and sub-criteria were obtained by expert 1, all the experts were enquired to give ratings for all the criteria. After obtaining all the ratings, the weights of all the criteria were obtained using equation (2) given above. The aggregated weights after solving equation (4) for data obtained and consecutively taking their average are presented in Table 6 below.

4.3. Ranking of airports using the VIKOR method

In phase 2, the weights of all the criteria of green evaluation were obtained and involved the ranking of selected airports with respect to weights of these criteria. VIKOR methodology as discussed in section 3 was employed for ranking these airports. All the experts were asked to give preferential ratings for each airport using the scale as shown in Table 3. The ratings given by expert 1 for each airport with respect to green evaluation criteria are shown in Table 7.

Similarly, all the experts were requested to rate the airports with regard to the evaluation criteria. The average rating of all the experts obtained using equation (3) is presented in Table 8. Using equations (4) and (5), the maximum and minimum value of criteria were also obtained and is presented in Table 8.

Further, using equations (6)–(8), the values of S, R, and Q were calculated, which is shown in Table 9. The airports were ranked on the basis of Q values, the alternative having the lowest Q value was selected as the best alternative subjected to satisfying two conditions as mentioned in step 7 of the phase 3 of methodology. Here airport 4 (AP4) obtained the first rank, as it has the lowest Q value and also satisfied both the conditions, i.e., Q (AP2) – Q (AP4) ≥ 1/(5–1) and also Q (AP4) obtained the first rank according to both the R and S values as shown in Table 10.

5. Sensitivity analysis

Sensitivity analysis is a powerful tool to check the robustness of the model and eliminate biasness during data collection and analysis (Prakash & Barua, 2015; Gupta & Barua, 2017). In order to execute sensitivity analysis, the weight of green evaluation criteria in the main category that got the highest weight (GPR in this case) varied from 0.1 to 0.9 and subsequently, the weights of all the main category criteria also varied. In total, ten different runs were performed in sensitivity analysis. Table 11 shows the weights of all main criteria related to the variation in the weight of GPR.

After obtaining the weights of the main criteria for different runs, these weights were subsequently used to calculate the weights of sub-criteria. Using the weights of sub-criteria for nine different runs, the VIKOR analysis was performed for each run to obtain the ranks for the alternatives. The ranks of the alternatives for nine different runs are presented in Table 12 below.

The S, R, and Q values for nine different runs depicted that there is no variation in original rankings and airport 4 obtained the highest rank in all the scenarios, thus, the model is robust and free from any bias.

6. Discussion of results

BWM is used to rank the criteria for evaluating the green performance of the airports. Among the criteria of the main category, Green Policies and Regulations (GPR) is considered to be the first criterion. Regulatory pressure is the major steering force behind implementation of green practices at the airports. The governments are continuously putting pressure on airport authorities to transit the operations from traditional to green. This transition helps in improving the overall productivity as well as assets utilization apart from environmental benefits (Pauwels & van Hoeve, 2010; Uysal & Sogut, 2017). Green Building and Infrastructure (GBI) is considered as the second criterion. The designing and developing of proper infrastructure is of prime importance for transiting to green airports. It is estimated that the development of green infrastructure alone leads to around 70% of the energy savings in the airport (Uysal & Sogut, 2017). The framing of green policies for developing green infrastructure at airports is beneficial to achieve the objectives of greening the airports. Air and Noise Control (ANC) is considered as the third criterion. Airports are significantly contributing to air and noise pollution worldwide, which has resulted in global warming (Uysal & Sogut, 2017). Airport emissions are

Table 7
Rating of alternatives by Expert 1.

	ANC1	ANC2	ANC3	ANC4	ANC5	GBI1	GBI2	GBI3	GBI4	GBI5	GBI6	GBI7	WRP1	WRP2	WRP3	WRP4	WRP5	WRP6	EMC1	EMC2	EMC3
AP1	2	1	2	1	1	4	3	1	1	1	1	1	1	2	4	2	5	3	4	3	2
AP2	1	3	3	1	2	5	5	4	1	1	1	4	2	2	5	3	5	1	5	5	1
AP3	4	4	1	4	1	1	2	1	5	5	4	3	3	2	4	2	3	3	3	2	5
AP4	4	4	5	4	2	2	2	5	5	2	4	1	5	3	1	4	3	1	4	4	5
AP5	5	1	5	4	1	3	3	2	5	5	3	2	5	3	3	1	4	3	5	2	4

	EMC4	EMC5	EMC6	EMC7	GOT1	GOT2	GOT3	GOT4	GOT5	GOT6	EGT1	EGT2	EGT3	EGT4	EGT5	EGT6	GPR1	GPR2	GPR3	GPR4	GPR5	GPR6
AP1	4	5	1	3	2	5	4	3	5	5	2	3	4	3	5	4	1	1	5	1	5	5
AP2	2	1	1	4	1	1	3	3	3	1	2	3	1	2	1	4	2	2	3	3	5	1
AP3	2	4	5	5	2	3	2	1	2	2	4	2	4	5	3	5	3	4	2	4	3	3
AP4	5	2	3	4	4	4	4	4	5	4	5	2	4	4	4	5	5	4	3	4	5	3
AP5	2	1	3	5	3	2	1	4	3	4	1	4	5	5	4	4	3	3	5	5	2	3

Table 8
Aggregate rating of alternatives by all the experts.

	ANC1	ANC2	ANC3	ANC4	ANC5	GBI1	GBI2	GBI3	GBI4	GBI5	GBI6	GBI7	WRP1	WRP2	WRP3	WRP4	WRP5	WRP6	EMC1	EMC2	EMC3
AP1	2.75	3	3.25	1.75	2.25	3.75	4	2.5	2.75	3.25	2.75	2.5	4	2.75	3.5	1.5	5	2.75	3.5	2.5	3
AP2	3.75	3.75	3.75	3.5	1.75	3	2.75	3.25	3.75	3.25	2	2.25	3.5	3	1.75	3.25	2.5	3	2.5	3	3.75
AP3	2.75	2.75	1.5	3.5	2	2.5	2	2.5	2.5	3	2.25	3.25	3.5	2.25	2.75	2.5	1.75	2	3.25	2	4.25
AP4	3.75	3.25	3.75	3	3.25	4.5	3.5	4.75	3	2.75	3.25	3.5	3.25	3.75	4	4.5	3.5	2.75	3.75	3.75	3
AP5	2.25	2.75	3.25	3.25	3.25	2.25	2	3.75	3.25	3.25	3.25	2.5	3.5	3	3.5	3	4	2.5	2.5	1.75	4
f_b^*	3.75	3.75	3.75	3.5	3.25	4.5	4	4.75	3.75	3.25	3.25	3.5	4	3.75	4	4.5	5	3	3.75	3.75	4.25
f_b^-	2.25	2.75	1.5	1.75	2	2.25	2	2.5	2.5	2.75	2.25	2.25	3.25	2.25	2.25	1.5	1.75	2	2.5	1.75	3

	EMC4	EMC5	EMC6	EMC7	GOT1	GOT2	GOT3	GOT4	GOT5	GOT6	EGT1	EGT2	EGT3	EGT4	EGT5	EGT6	GPR1	GPR2	GPR3	GPR4	GPR5	GPR6
AP1	3	4	2.25	3	3.25	3.25	3.5	3.5	4	2.75	3	3	2.75	3.25	3.5	4.5	2.5	2	3.5	3.25	3.75	4
AP2	2.5	1.5	1.5	2.5	3.5	4	2.75	3.5	2.75	2.5	2.75	3.25	3	3.5	3	3	3	2.5	3.5	3	4	4.25
AP3	3	3.75	4.25	2.75	1.75	3	2.25	1	2.5	4	2.25	2.25	4.25	3	3.25	2.75	2.75	4.25	2.5	4.25	2	2.75
AP4	2.75	3	4	3	2	4	3.75	4.25	3	2.5	2.75	3.25	2.75	3.75	3.5	3.75	2.75	4.25	3.5	3.5	5	3.5
AP5	2.75	2.5	2.25	3.5	2.5	2.75	3	2.75	3.5	4.25	3.25	3.75	4	2.75	3.75	3.5	3.25	2.75	3.25	4.25	2.25	2.75
f_b^*	3.5	4	4.25	3.5	4	4	3.75	4.25	4	4.25	3.25	3.75	4.25	4.25	3.75	4.5	3.75	4.25	4	4.25	5	4.25
f_b^-	2.75	1.5	2.25	2.5	1.75	2.75	2.25	1	2.5	2.5	2.25	2.25	2.75	2.75	3.25	2.75	2.5	2	2.5	3	2	2.75

Table 9
S, R and Q values for alternatives.

	S	R	Q
AP1	0.482	0.096	0.714
AP 2	0.407	0.075	0.478
AP 3	0.714	0.102	1.000
AP 4	0.231	0.035	0.000
AP 5	0.563	0.070	0.607
	$S^- = 0.714$	$R^- = 0.102$	
	$S^* = 0.231$	$R^* = 0.035$	

Table 10
Ranking of alternatives for R, S and Q values.

	S	Rank	R	Rank	Q	Rank
AP 1	0.482	3	0.096	3	0.714	4
AP 2	0.407	2	0.075	2	0.478	2
AP 3	0.714	5	0.102	5	1.000	5
AP 4	0.231	1	0.035	1	0.000	1
AP 5	0.563	4	0.070	4	0.607	3

rapidly increasing and have led to high discharge of CO_2 in the environment (DGCA, 2013). Noise pollution is also equally concerning and many complaints have often been raised. Strict policies to restrain air and noise pollution are the need of the hour and are considered essential by airports all over the world (Licitra & Ascari, 2014; Netjasov, 2016).

Among the criteria under the subcategory, the financial regulatory framework for low carbon and climate change (LCR) infrastructure (GPR3) is considered as the first criterion. Airport carbon accreditation by the ACI (airport council international) (GPR2) is the second subcategory that is given the most importance. ACI is an international agency for accreditation and monitoring of airports worldwide, they should be given responsibility to monitor the carbon footprint emissions by airports and then evaluating the airports on the basis of this criteria. This will cause the airports to stringently follow the carbon reduction policies and thus improve their overall green performance. Green building design and Retrofitting practices (GBI1) is considered as the third most important subcategory. Proper designing of the infrastructure and airport space is essential to convert the current airports to green airports. The designing of eco-friendly lounges, recycling technologies, and green fleets lead to overall greening of the airport. Further, the adoption of retrofitting practices for transition to green infrastructure is beneficial. The cost of transition is very high and the major concern faced by airports as well as the governments is the availability of finances; hence, the adoption of retrofitting practices with current infrastructure is the cheaper and easier way to achieve the objective of greening the airport (Ferrulli, 2016; Upham et al., 2003). The next subcategory that is given importance is compliance with global environmental laws and regulation (GPR1). Global agencies like United Nations Environmental Protection Agency and many others are constantly making laws for the protection of the environment. Energy efficient material for building construction (GBI4) is the fifth most important subcategory. Many energy efficient materials and technologies are available these days to reduce energy utilization, which in turn diminish costs and save energy. These materials include recycled steel, insulated concrete forms, polyurethane, straw bales, cool roof, plastic composite lumber, etc. These energy efficient materials can lead to drastic energy savings through lesser energy consumption and are essential for the greening of the airports (Gupta & Barua, 2016a).

After ranking the green performance criteria, few airports were selected and ranked on the basis of these criteria using the VIKOR method. The airports have been ranked as follows AP4 > AP2 > AP5 > AP1 > AP3. The results showed that AP4 is showing the best performance according to these green performance criteria, and the authorities of other airports can follow the practices of AP4 to achieve their goals of greening the airport.

7. Conclusions, implications, and scope of future work

In order to become an environmentally sustainable or green airport by 2030, Indian airports need to implement green practices in their core competencies due to strict global environmental norms and regulation. The increased competition has given attention to airport authorities for adopting green practices in their organizational and operational activities. It can reduce the impact of hazardous emissions and improve environmental performance significantly. In this study, a novel approach of the Best-Worst and VIKOR methodologies have been used to prioritize the enablers of green practices and select the best airport in accordance with sustainable environmental performances and efficiency in air transport service. The study makes the first attempt to take into account various criteria of green practices for the airport. Based on the literature and experts opinions, seven main criteria and 43 subcriteria were identified. In addition, this paper has employed multiple organizational theories such as RBV, INT, ST, and EMT, which provide theoretical underpinnings for rationalizing the criteria and even present numerous valuable insights about the airport stakeholders' decision-making process related to the designing of organizational framework by enhancing environmental competencies to achieve sustainable and economic gain.

Based on the empirical analysis, green policies and regulation (GPR) has emerged as the most important main criteria of the green airport, and this criterion belongs to the governance affair. Similarly, green building and infrastructure (GBI) and air and noise control (ANC) have obtained the second and third ranks, respectively, in the best worst analysis. These particular main criteria are referred to as organizational issues. Moreover, the government and various regulatory body's support are vital for adopting green innovation activities and waste management practices (Freestone & Baker, 2010; Gupta & Barua, 2017; Kumar & Dixit, 2018a). To enhance the environmental performances, Indian airport requires a well-designed green building and logistics infrastructure to resolve the complexities in product return and recycling for their extended reuse (Kumar & Dixit, 2018b). Besides these key criteria, the other criteria cannot be ignored, as those criteria help in achieving the goal of green innovation and competitiveness in the organizations. Further, a ranking of five Indian airports with reference to these criteria using the VIKOR method is presented and the results

Table 11
Variation in weights value for all main criteria after varying GPR weight value.

Criteria	Normalized Weight	Run 1 (0.1)	Run 2 (0.2)	Run 3 (0.3)	Run 4 (0.4)	Run 5 (0.5)	Run 6 (0.6)	Run 7 (0.7)	Run 8 (0.8)	Run 9 (0.9)
GPR	0.335	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
GBI	0.226	0.306	0.272	0.238	0.204	0.170	0.136	0.102	0.068	0.034
ANC	0.122	0.165	0.147	0.129	0.110	0.092	0.073	0.055	0.037	0.018
GOT	0.116	0.157	0.140	0.122	0.105	0.087	0.070	0.052	0.035	0.017
EMC	0.085	0.115	0.102	0.090	0.077	0.064	0.051	0.038	0.026	0.013
WRP	0.077	0.104	0.092	0.081	0.069	0.058	0.046	0.035	0.023	0.012
EGT	0.039	0.052	0.046	0.041	0.035	0.029	0.023	0.017	0.012	0.006

Table 12
Ranking of the airport after performing nine runs in sensitivity analysis.

	Run 1			Run 2			Run 3		
	S	R	Q	S	R	Q	S	R	Q
AP 1	0.464	0.054	0.341	0.471	0.057	0.456	0.479	0.086	0.707
AP 2	0.429	0.064	0.395	0.419	0.057	0.395	0.410	0.067	0.478
AP 3	0.750	0.085	0.904	0.735	0.075	0.904	0.719	0.092	1.000
AP 4	0.241	0.040	0.000	0.237	0.036	0.000	0.232	0.031	0.000
AP 5	0.598	0.095	0.851	0.583	0.085	0.848	0.568	0.074	0.700

	Run 4			Run 5			Run 6		
	S	R	Q	S	R	Q	S	R	Q
AP 1	0.486	0.115	0.726	0.494	0.144	0.745	0.502	0.172	0.765
AP 2	0.401	0.089	0.477	0.392	0.112	0.476	0.382	0.134	0.475
AP 3	0.704	0.122	1.000	0.689	0.153	1.000	0.674	0.183	1.000
AP 4	0.228	0.042	0.000	0.224	0.052	0.000	0.219	0.062	0.000
AP 5	0.554	0.077	0.559	0.539	0.096	0.556	0.524	0.115	0.552

	Run 7			Run 8			Run 9		
	S	R	Q	S	R	Q	S	R	Q
AP 1	0.509	0.201	0.786	0.517	0.230	0.808	0.524	0.258	0.831
AP 2	0.373	0.156	0.474	0.364	0.179	0.473	0.354	0.201	0.471
AP 3	0.658	0.214	1.000	0.643	0.244	1.000	0.628	0.275	1.000
AP 4	0.215	0.073	0.000	0.211	0.083	0.000	0.207	0.094	0.000
AP 5	0.510	0.134	0.549	0.495	0.153	0.545	0.480	0.172	0.542

showed that airport 2 is the best performing airport on the basis of green abilities and practices.

Finally, this study has employed a novel integrated framework, which provides many implications for academia, managers, and stakeholders having knowledge about the top enablers of the green airport. The stakeholders of Indian airport can work to enhance these important enablers in their organizational activities, which encourage the pursuing of the global environmental regulation and norms. Apart from these, this novel framework provides a fruitful insight to managers and various stakeholders of Indian airports to foresee future green developments with regard to global environmental and climate change issues and to take proactive measure while designing the green policies and strategies for the airports.

In consideration with every research work, this work also has some limitations. Firstly, this study is focused primarily on Indian airports, and thus, a generalization of the results for other airports across the world can be a major challenge. Hence, future studies can be conducted by evaluating airports across two or three countries for better generalization of the results. Moreover, this study is limited to 43 evaluation criteria identified through expert opinion and literature review, so future studies can focus on identifying more such criteria for evaluating the green performance of the airports. Lastly, this study has used MCDM techniques like BWM and VIKOR for ranking the criteria and alternatives. It is known that many of these criteria are interrelated and depend on each other, so future studies must try to explore this relationship by adopting techniques like ISM, DEMATEL, and SEM for getting robust results. However, the use of different methodologies might involve different experts and since MCDM methodologies are totally based on expert opinion, so the results can vary in each case.

Author contribution

Ashwani primarily helped in theory building and literature review. He also helped in data collection. Aswin helped in literature review and data collection along with introductory part of the manuscript. Himanshu Gupta was involved in data analysis, result and discussion of the manuscript apart from literature review.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tourman.2019.06.016.

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