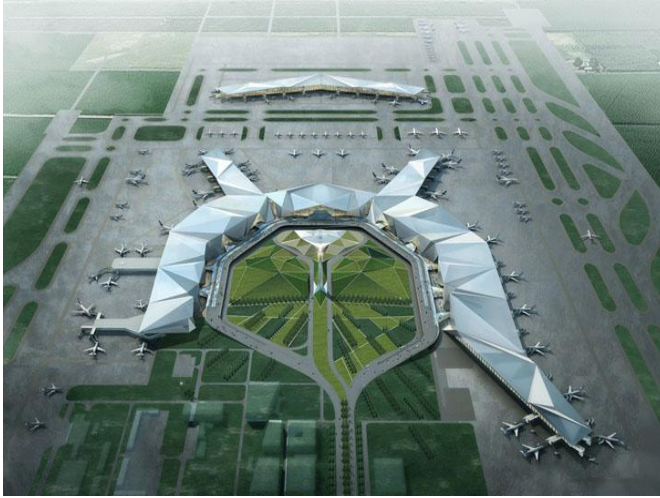# Green Airports- Solution to Stop Pollution!

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I. INTRODUCTION

The impact of greenhouse gases is currently noticed by the changes in the environment which are the signs for warnings of future catastrophic consequences. This has promoted an urge to research that focuses on developing sustainable technologies and are also environmentally friendly. Measures have been implemented to limit all possible sources of pollution. It is to be noted that "Aviation" is a major contributor of air pollution, which has evaded all radar screens and is still unregulated. While aviation manufacturers are busy researching to find greener ways to fly, many architects are aiming in constructing environmental friendly airports.

The idea behind Green Airport is to create a centre of sustainable practices which incorporates research and innovation along with ongoing aviation activities such as flight training, aviation and environmental education, recreational flying, eco-tourism and scheduled commuter operations.

The growth of an airport is limited by factors such as noise pollution, environmental allowances, physical space required and quality of life there in and around the area. In addition, many airports face serious image problems in the community, which constitutes another limiting factor.The implementation of green airport will serve as a catalyst to promote energy independence and simultaneously improves economic conditions.Sustainable investments are seen as mandatory investments that lead to value creation for the airport.Along with the environmental aspects there is to be consideration for economic aspects.

II. NECESSITY

It is very well known that aviation sector plays an indispensable and magnificent rolein global economy, but the fact that it also contributes to greenhouse gases and the other pollution factors that are causes of anthropogenic climate changes and environmental impact is a controversy. The two major concerns involved with the environmental impact of airports are noise and emissions. Apart from these there are other airport activities that significantly affect the environment. Some of them are related with the operation of ground equipment on airport premises, cargo, and transfer of baggage and vehicle traffic around the airport. It is obvious that airports use large portions of land that contribute to air and ground water pollution, also produce vast amounts of waste, and consumes excess energy. The aviation industry has been slow in taking initiative towards any energy efficient systems and waste reduction strategies.
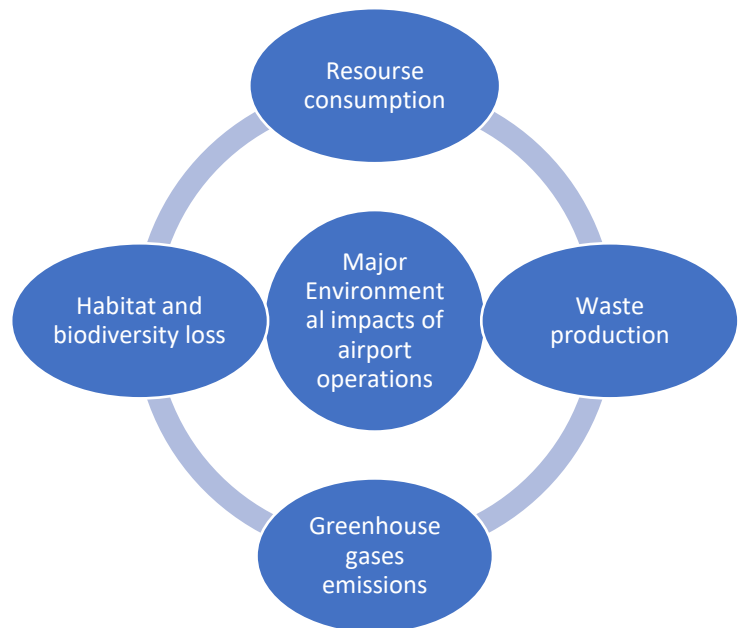
In the present globalized world, there are many positive impacts because of air transportation in the social life of the people and the industry related, but a look over the other side proves that there is huge negative impact on pollution. The

critical problems that could be stated are air pollution, climate change, landscape deterioration, water pollution and biodiversity damage. Incidents of bird strike, air pollution caused affects the ecosystem of the area that contributes to loss of biodiversity. Edacious use of electricity and the pollution are major concerns because the outcome gases like CO2, NOX contributes to concentration of greenhouse gases that adversely affects the climate.

To improvise the environmental record, vital measures have been taken in up gradation of airports and concerned infrastructures. A modern approach to reconcile present day requirements of society along with environmentally friendly practices has resulted in the concept of "Green Airport". Combination of smarter engineering techniques and determination of few nature friendly operators have made this concept a success.Instead of just making an attempt to alleviate the environmental impact of existing systems it would rather focus on adopting the sustainable, renewable energy technologies and environmental friendly providing a model for ground-breaking practices that also contributes in reducing pollution.

III. A WORLD TOUR

The importance of green airports made many unique minds think about practical ways to begin it. The urge for green airports wasn't at a rapid rate, but after knowing the positive outcomes and results of green airports many nations started investing in it. There are few of the world's best green airports listed down:

- Chicago O'Hare International Airport
- Galapagos Ecological Airport
- San Diego International Airport
- Toronto Pearson International Airport
- Amsterdam Schiphol Airport
- Denver International Airport

An attempt is made to analyse three of the airports mentioned above. They are:

i. **Seymour Airport:** Commonly known as Galapagos Ecological Airport, built in 2012 is acclaimed to be world's primordial green airport. It runs only on wind and solar power. Majority, almost 80 percent of the airport's infrastructure was constructed using materials that has been recycled from the old building. Presence of mechanical shutters which open and close based on level of carbon dioxide and heat of the building has made it unique construction. Other remarkable green feature associated with Seymour airport includes presence of desalination plant which helps in converting the local seawater.

PICTURE 1: Image of Seymour Airport

ii. **Chicago O'Hare International Airport:** This international airport is located on the Far Northwest Side of Chicago, Illinois. Though it is one of the hustling terminals in the world, it has ensured it is not deficient in its green technologies on comparison with other eco-friendly counterparts. In recent times many local organisations have actively participated to provide sustainable solutions. Several initiatives were taken by the Department of Aviation to make the environment in airport eco-friendlier. Rain water harvesting, installation of solar panels using renewable source such as wind turbines for energy productions, recycling waste water, rooftop garden, electric vehicle charging stations are some initiatives that was started.

The CDA and HMS Host Corporation collaborated in the year 2011 to build in an aeroponic garden, i.e. method of growing plants without soil. O'Hare was the first airport in world to get aeroponic gardens. It was equipped in the mezzanine level of the O'Hare Rotunda Building where roots of the plant are suspended in almost 26 towers that houses over more than 1,100 planting spots. Comparatively cultivating an aeroponic garden procure numerous advantages over a customary one. Supreme benefits of acquiring an aeroponic garden within O'Hare is that many of restaurants present there such as Tuscany Cafe, Wicker Park Sushi, Wolfgang Puck, and Tortas Frontera and gather the fresh cultivated there, which is used in food served for passengers. Few of the O'Hare's Garden Product are Swiss chard, Bibb lettuce, Genovese basil, Sweet basil, Purple basil, Cilantro, Dill, Parsley, Chives, Gourmet lettuce mix, Red lettuce, Habanero peppers.

PICTURE 2: Image of O'Hare Airport

iii. **Denver International Airport:** Also known as DIA or DEN, is one world-renowned airport for its pioneering Environmental Management System (EMS) and is located in Denver, Colorado, United States. It is popular for its environmental performance, eco-friendly environment, use of natural gas for operation and energy efficiency. It is one among the Gold Certified airports under Leadership in Energy and Environmental Design (LEED), which is the widely used green building rating system. DEN uses natural gas to heat over 5.5 million square feet of the premises and is used to supply fuel for the airport's bus and vehicle fleet.

PICTURE 3: Image of DEN Airport

Environmental Management System (EMS) was a systematic approach developed in DEN to identify and mitigate all potential impacts to the environment because of the airport operations. It was the first international airport in the United States to get its EMS certified to the ISO 14001 international standard, which ensures that the airport's EMS has the most recent accepted practices and procedures for identifying and analysing the impacts caused to environment and take measures to control it by promoting the internationally accepted methods. DEN became chief commercial airport in U.S. in the year 2013 to design a comprehensive plan of Area Navigation (RNAV). This approach saves almost 200-800 pounds of fuel per flight, reducing fuel consumption and wastage and less emissions. 5,400 parking garage lights were replaced with energy-efficient LED fixtures in the year 2014 that helped in reducing electricity cost by saving $327,000 per year.

IV. INDIA'S GREEN AIRPORTS

India is ranked among the top 5 rapid growing countries for airport transport passengers. According to reports from fiscal 2015-2016, Indian airports are estimated to have almost 223.6 million passengers. Green airports are gaining a momentum in India. Till date, India has two green airports. They are:

i. **Cochin Airport:** CIAL has 46000 solar panels installed and sounds like set of sci-fi film than a conventional airport because of its impressive technology. The unique strategy of powering the whole airport only through solar have bought fame to the nation, it is India's first green airport. The plan was initiated with by using solar panels in a rooftop of the arrival terminal in early March 2013.

PICTURE 4: Image of Cochin Airport

ii. **Vadodara Airport:** It is also known as Civil Airport Harni and is the second green terminal in the country after Cochin. Its terminal was constructed by the

Airport Authority of India(AAI) at accost of Rs.160 crore and this terminal will be increasing the passenger capacity from 450 to 700.The airport is said to be constricted with principle of green infrastructure using bricks of fly ash. The terminals have advanced security management with energy-saving cooling, fire safety and rainwater harvesting.

PICTURE 5: Image of Vadodara Airport

V. CASE STUDY

A case study was done on two airports to know the techniques followed to be categorized as "Green Airports" and set a benchmark for other airports, namely Oslo airport and Cochin Airport.

1) *Oslo Airport:* Located in Oslo, Norway is an international airport serving as second busiest airport in Nordic countries. It boasts to have the greenest airport terminal in the world and also possess an array of energy efficient strategies. This has increased the capacity of passengers to 32 million per year. The new terminal built is double the size of the existing terminals i.e. 115000 square meters and also possess standards in sustainability. The Nordic Office of Architecture was in charge of the design of this green airport. Their focus was go procure environmental friendly building materials, bring innovative energy solutions and waste management techniques. This was the first airport that gained the designation of scoring an excellent rating in Building Research Establishment Environmental Assessment Method (BREEAM). It is well seen from the outcomes that in every aspect of the work a strong approach was taken for sake of environment. The slope of the wooden roof terminal was designed to make maximum use of daylight, in simple words in a way that it minimizes solar heat gain or loss. Artificial lightning is minimized in favour of natural lightning in order to improve passengers comfort and

reduce energy demands. The designers have made efficient use of space which is a testament because despite the increase in size of the airport, the walking time to the gates remains the same. The firm also updated the overhaul of the existing train at centre of airport, enabling 70 percent of the passengers to access airport by public transport reducing the traffic and pollution around the airport. The most notable energy saving measure is the design that incorporates a system of reservoirs, in which snowfall can be harvested and is covered with an insulating sawdust. This collection and storage of snow served as a coolant during summer seasons.

PICTURE 6: Image of Oslo Airport

PICTURE 7: Recycled ash and concrete used for construction

The architects design was not only about technology and metrics, they showed more concern about the dimensions of sustainability. The idea of green atmosphere to meet up the social aspects of sustainability was done by using water features, vegetated green walls and planting pine trees

throughout the interior. To minimize the building's energy footprint materials such as local timber and environmentally friendly concrete made of local volcanic ash was used. The new pier is completely clad in timber that are sourced from Scandinavian forests, while additional natural materials, green walls are found throughout the interior. The use of natural materials and recycled materials for building purposes has reduced the CO_2 emissions by 35 percent. Enhanced levels of insulation have helped the building achieve Passive House-level performance standards and coupled with energy harvesting, energy consumption by 50 percent compared to the existing terminals. The retail stores in the duty-free sections of the airport uses organic stone forms associated with Norwegian landscapes to further impress the passengers. The terminal project in terms of waste management has achieved a sorting grade of 91 percent, which means that only 9 percent of the discarded construction materials falls under the category of general waste while the remaining is sorted and handled. The holistic efforts to make it a sustainable terminal has made Oslo Terminal as an inspiration for many airports.

PICTURE 8: Image of Oslo Airport

2) *Cochin Airport:* The impressive part of Cochin International Airport Limited (CIAL) is when it started its strategy of tapping of solar energy with almost 46000 solar panels installed and it is the first megawatt scale solar power plant in Kerala. The solutions for the airport was developed by Public-Private Partnership (PPP), which has the brought the fame to Cochin airport to be the first airport in the world to be completely powered by solar energy from18.08.2015. A single plot of 45 acres (184,668 m²) was used for the project by Cochin International Airport Limited (CIAL) authorities. The solar plant is located near to the cargo complex of airport (10.157 N, 79.383 E) at an altitude of 6 m. The site is estimated to receive ample amount of global horizontal irradiation throughout the year (1930.9 kWh/m²/year). The huge solar panel produces almost 50000 to 60000 power units a day, making the Cochin airport to be absolutely power neutral, which has helped to save 300000 tonnes of carbon emissions.

PICTURE 9: Image of Cochin Airport

The 12 MW project's estimated cost was around INR 620 million, which took almost six months for implementing. It has the capacity to produce 18 million power units per year which is sufficient to serve annual need of 10000 homes. The airport sells the energy produced through electricity grid to the Kerala State Electricity Board. The recent records state that the units of electricity purchased from KSEB is equal to or more than that exported to grid that makes the Airport self-sufficient and sustainable in terms of electrical energy consumptionThis innovative approach saves money on a long run and consumes only 48000 units of power a day. During the over cast days, the energy can be supplied from the local state electricity grid, thereby increasing the reliability of solar power.

PICTURE 10: Image of solar panels in Cochin Airport

The environmental benefit of this solar powered airport corresponds to the reduction in carbon foot print of electricity generated by system on comparison with thermal plants. Replacing the thermal power plants with solar power will reduce the emission of harmful gases such as CO_2, NO_2, and SOX etc. The carbon payback of solar PV systems is important as the PV module manufacturing process is energy intensive. Solar systems preserve water sources, unlike fossil fuel-based power plants that requires water to generate electricity. Sreenath et al., (2017) monitored the 12 MWp grid connected PV system located at Cochin Airport between Sept 2015 to Aug 2016 and its performance was evaluated on monthly average daily basis. The environmental benefits of solar PV system are given in table 1.

Table 1: Environmental benefits of solar PV system.

Emission	Amount avoided per year
Carbon dioxide	12134.26 Metric tons
Nitrogen dioxide	24532.58 pounds(lbs)
Ozone	27649.78 pounds(lbs)
Sulphur dioxide	59878.5 pounds(lbs)
Water	335 million gallons

Cochin airport presents an excellent opportunity for other airports in India to build such projects targeting towards low emission model. It also provides an awareness and commitment towards climate changes and carbon emission caused by the airports.

VI. ATTEMPTS IN INDIA

Green airports are gaining momentum in India because India's aviation sector is growing at a rapid rate. They are becoming a necessity all around the country for its advantages such as traffic density, carbon emissions control and for reliable support in areas of finance and sustainability.

❖ *Efforts of DGCA:* As per DGC Airports in 2013, Indian airport have emitted 5 percent of total CO_2 emissions i.e. around 0.78 million tons. Environmental Unit formed by DGCA to look into environmental issues, guide and solve noise pollution issues, reduction of greenhouse gas emissions. The EU- Indian Civil Aviation Cooperation Programme started to back sustainable economic growth and to improve the federation capacity of civil aviation industry of India.

❖ *Development of standards:* An anonymous level was built to assess the airports based on their action model to decrease greenhouse gases emissions. This is acknowledged as "Airport Carbon Accreditation"- a carbon management certification standard refined by ACI Europe. The programme recognizes the efforts taken by airport to reduce the greenhouse gas emissions. Delhi, Bangalore and Mumbai airports have been granted level III accreditation under Airport Carbon Accreditation Programme 2013-2014.

❖ *Efforts by busy airports:* Like Cochin, many Indian airports have come up sustainable measures to address the issues. The solution is not all about installing green energy and solar panel, but a universal system comprising feasible measures at all possible ways. Few Indian airports that have addressed their issues are:

a) *Indira Gandhi International Airport:* Commonly known as Delhi International Airport (DIAL) has been ranked fourth in list of World's best airports. It also comes up with solutions to protect environment. They have reduced greenhouse gas emissions by bringing in a catalogue at organizational level computing greenhouse gas emissions through Carbon Accounting and Management system. Terminal 3 of DIAL incorporates energy efficient technologies such as solar boundary light system, energy efficient chillers, solar water heating systems, tempered cooling systems, energy saving through improved taping in supply air and return air ducts and chilled water pipe circuit. Other initiatives in Terminal 3 that has helped in significant reduction of greenhouse gases are electrically functioning baggage tugs, CNG gas station.

b) *Chhatarapti Shivaji International Airport:* Popularly known as Mumbai Airport is India's second most engaged airport. This objective of airports to become

carbon neutral has made it earn ISO 14064- 1:2006 certification for its Carbon Emissions computing. The airport has made attempts in managing GHG emissions, water usage, and use of energy, waste production and surrounding air quality. Replacement of bulbs with LED has helped to reduce loss in electrical system. A solar power plant with capacity of approximately 600KW has been installed to convert the place that holds strategy of energy efficient systems and sustainable practices.

c) *Kempegowda International Airport:* Better known as Bengaluru Airport has received Gold rating in LEED, a US based green rating system by the Indian Green Building Council appreciating its sustainable, eco-friendly and energy efficient building patterns. They have brought up an idea of installing a 2MW solar plant that would upgrade the overall energy efficiency and recede carbon footprint.

d) *Rajiv Gandhi International Airport:* The Hyderabad Airport is conferred with the Golden Peacock Award for the steps it had taken to integrate sustainability and environmental protection as a part of business policy. A 273-hectare green belt has been planted to strike an ecological balance, besides 971 hectares of natural greenery remains fresh. This sets a benchmark by addressing to the issue of biodiversity that is endangered by many airports that leads to habitat loss and destruction of natural eco-system. Initiatives have been taken to develop water treatment plants. The have adequately compressed almost 3331 tons per annum of carbon footprint through their conservative methods.

❖ *Efforts in Andhra Pradesh:* The Government of India galvanizes the idea behind green airports and supports it. Airports Authority of India (AAI) have taken initiatives in developing green airports in districts of Andhra Pradesh. AAI has originated byinstalling 1MWp solar power plants at Tirupathi and Vijayawada Airports, for its captive power consumption.

VII. SUGGESTIONS

Most of the airports have attained their goal of sustainability and eco-friendly through adoption of various technologies. The overall study has helped to make some valuable suggestions on the method developed for being Green airports. They are:

➢ Use of renewable source of energy for operations instead of non-renewable sources. Renewable sources such as solar, wind have proved to be sustainable, more efficient and their contribution towards pollution is at minimal rates.

➢ Energy conservation techniques such as usage of LED, roofing with appropriate materials that absorbs energy and helps to transfer. Energy efficient methods like lighting on demand need to be followed.

➢ Reduce, Reuse and Recycle wherever applicable and follow waste management strategy.

➢ It is important to ensure that there is no loss to biodiversity in the area that is to be taken away for construction of airport and no loss of habitat for any species which would affect the ecosystem. Avoid interventions on natural heritage which can minimise the impact on biodiversity.

➢ Water treatment plants and rain water harvesting methods to prevent water shortage.

➢ Reduce noise emission through various noise mitigation steps.

➢ Aeroponic farming to be cultivated in airports. This type of gardening uses the technique of growing plants without soil. In this vertical farming roots are misted with a nutrient solution during a regular watering cycle. Production and purchase of these provincially grown foods in airports creates a platform by supporting local economy and territorial job market, minimizing urban sprawl, habitat loss, traffic profusion and pollution caused by transporting and producing the ingredients purchased outside, thus maintaining the liability towards sustainability.

➢ Give priority to environmental integration, rehabilitation and improvement of existing infrastructure rather than starting from scratch. This can preserve soil resources and reduce the degradation of soils and groundwater.

➢ Developing more standards such as LEED that can be awarded for the airports if they take innovative measures in achieving their sustainability goals.

➢ Encouragement of programmes, rules initiated by organizations such as DGCA to monitor performance of airports and their contribution levels in pollution.

➢ Consumption of bio-fuel for air side vehicles, innovation in efficient flight tracking system in order to optimize the flight take-off and landing time.

➢ Encouragement of ideas from private sectors for the infrastructure and creating awareness among students.

VIII. CONCLUSIONS

Being more comfortable and saving time, have made the way for aviation sector. Airports are advanced to meet this over growing requirement. This growth poses enormous challenges to environment and sustainability in upcoming years. There is a necessity to work in attaining sustainable development and guard environmental health by steps to eliminate the hazards caused by this sector. Green airports are the best step that could be taken to eradicate the issues faced in this sector. They are all about designing a sustainable ecosystem within

the airport and the surrounding areas. The sustainable efforts must be supported and followed.

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