ENVIRONMENTAL IMPACT OF THE FLYING SCENARIO: AN APPROACH TOWARDS SUSTAINABLE AIR TRANSPORTATION: A CASE STUDY OF INDIA

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Abstract: It is a well acknowledged fact that the air transport at present is the fastest growing and the safest mode of transportation. And with this current trend, it is expected to be further expanding all around the globe. In India, the aviation market has witnessed massive growth making India the ninth largest aviation market in the world. It is expected to grow into the third largest position in the world by 2020. With this increasing growth, development and consolidation of the aviation market, it is inevitable that it will have serious implications for the environment.

The harmful impacts of aviation on the environment are basically in terms of pollution (air, noise) and also in relation to the land use planning (for infrastructure use, terminals and runways). All of these ultimately contribute to climate change. Emissions from aviation are growing faster than any other mode of transportation. Also emissions from aviation is considered to be the fastest growing source of anthropogenic green house gases which include both CO2 and non-CO2 induced effects, as the aviation emissions have a greater climatic impact because aviation is the only sector in which bulk of gases are emitted in altitudes between 9 km and 12 km leading to a stronger climatic effect than from the emissions made at ground level. At current rates, with the amount of growth seen in this industry, it is expected that the share of emissions from the aviation sector to total greenhouse gas emissions will increase to about 20 per cent by 2020.

In India explicitly the first annual report on 'The Carbon footprints of Indian aviation' presented by the Directorate General of Civil Aviation (DGCA) shows a 6 per cent increase in Carbon dioxide level in the year 2011. This report is a part of the strategy of developing a sustainable aviation framework for the fast growing Indian aviation sector. According to the report, combined operations from both the Indian domestic and International scheduled operations accounted for about 13 million tonnes of CO2 in 2011, which shows a 6 per cent increase in comparison to 2010. This clearly depicts that although the Indian aviation market is a booming sector for the country's development, yet it is inevitably posing a lot of environmental challenges to be taken up with emissions getting more than doubled to 27 million by 2020.

The reliability on aviation and the environmental impact are becoming critical issues for the future of flights. Therefore in order to reduce the harmful effects of emissions on our environment, there is an urgent need to develop a sustainable aviation strategy. Environmental impact assessment both at the global as well as local level needs to be addressed while thinking globally and acting locally. Thus global initiatives must match with the local level actions while minimizing disturbance levels from flight tests, optimising energy and environmental performance of production facilities and buildings. In India, a real framework for environmental impact assessment does not exist except for the Aviation Environmental Unit proposed by the DGCA, which too has a limited capacity. ICAO on the other hand has itself failed on a global framework on emission reduction. So, these lapses need to be looked upon and further emission mitigation measures need to be

studied, highlighting this area of research for the sustainable development of our environment and further analysing how technology induced crises can be overcome by technology itself. This is the focus of this proposed paper.

Keywords: Aviation, climate change, emission mitigation, environment, sustainable air transport.

INTRODUCTION

In the recent years there has been a remarkable interest in the environmental issues, in sustainability and in the mitigation of such environmental challenges. Many global firms have been trying to work together in this growth of interest. Environmental Impact Assessment (EIA) thus became an important example of this. It was basically introduced in USA in the mid 1980's when an European Community Directive filed an application in EC member states. It was finally introduced in the UK in 1988, since then it has been considered as a field of growth in the planning practice. According to Munn (1979), EIA is broadly referred to the need 'to identify and predict the impact on environment and on the man's health and wellbeing of legislative proposals, policies, programmes, projects and operational procedures and to interpret and communicate information about the impacts.' In simple words EIA is basically an assessment of the impact of a planned activity on the environment. It is an aid to decision making and also acts as an instrument for sustainable development.

Therefore for a better understanding and knowledge of the environmental impact of any sector, it is very important to know what EIA actually means. This paper therefore tries to bring into notice the EIA of the aviation emissions. It is intended to raise the level of awareness about the increasing growth of global aviation and its environmental consequences. It tries to show the increasing growth and development of the Indian aviation sector and the measures that have been taken to reduce such emissions. Although the contribution of global aviation emissions as compared to other modes of transportation is less but the pollution created by airplanes is much more effective as it directly goes out in the atmosphere. This is one of the main reasons which need utmost attention and therefore requires a sustainable air transportation to reduce the emissions.

Aviation is considered to be the safest, fastest and the most efficient means of public transportation at present and is expected to outpace them in future. It does not have any geographical barriers and can cover long distances which no alternative means of transportation can do, making it one of the world's great connectors of people, trade and tourism. The aviation industry is a booming sector and plays a vital role in the economic development of any country. Over the past few decades there has been an immense amount of growth in this sector and in the coming future it may be even faster. In comparison with others, aviation has the highest growth rate of all modes of transportation. With this increasing trend in the airlines industry, the environmental impact on aviation is becoming a critical issue for the future of flights. The current level of emission are forecast to grow in absolute tonnes and even more so as a proportion to total emissions in the coming future.

The emissions from aviation

The aircrafts also produce the same type of emissions as automobiles. The aircraft jet engines produce Carbon dioxide (CO2), Nitrogen oxide (NO2), Carbon Monoxide (CO), Sulphur oxide (SOx), unburned or partially combusted hydrocarbons also called as volatile organic compounds (VOC), aerosols and their precursors (soot and sulphate). In addition to all this there is also increased cloudiness in form of persistent linear contrails and cirrus clouds.

METHODS AND MATERIALS

Research methodology

This paper is entirely a theoretical work based on the analysis and reports of the aviation organisations. The case study of India is based on extensive analysis of government documents and achieves.

Data on the current situation of Global Aviation emission

There is an impressive statistics that tells us about the trend in the aviation sector. From the population statistics from the year of Wright brother's first flight in 1903 it was 1.6 billion people which has now increased to 7.1 billion people [1], this high rate of population level can depict the growth and development and further in the demand for airplanes respectively. According to the *Air Transport action Group (ATAG*) [2] there are a few facts and findings that would give us an idea about the statistics in the global aviation sector in the present scenario.

(a) Over 3 billion passengers were carried by the world's airlines in 2012. (b) Worldwide, the amount contributed to the global economy by aviation jobs is roughly three and a half times higher than that contributed by other jobs. Over 56 million people are employed worldwide in aviation and related tourism. Of this, 8.36 million people work directly in the aviation industry. (c) The global aviation industry produces around 2% of all human-induced carbon dioxide (CO2) emissions. (d) Worldwide, flights produced 689 million tonnes of CO2 in 2012. Globally, humans produced over 34 billion tonnes of

CO2. (e) Aviation is responsible for 12% of CO2 emissions from all transports sources, compared to 74% from road transport. (f) While air transport carries around 0.5% of the volume of world trade shipments, it is over 35% by value – meaning that goods shipped by air are very high value commodities, often times perishable or time-sensitive. (g) Jet aircraft in service today are over 70% more fuel efficient per seat kilometer than the first jets in the 1960s. Globally, the average occupancy of aircraft is around 79%, greater than other forms of transport. (h) Around 80% of aviation CO2 emissions are emitted from flights of over 1,500 kilometres, for which there is no practical alternative mode of transport.

Environmental Impact of the flying scenario

The study of environmental impact on aviation can be broadly examined under the two categories namely local and global level. At the local level the impact can be seen with increase in GHG leading to air pollution, noise caused at the airport and airplanes, water quality, energy. At the Global level the effects in the form of climate change and global warming.

Noise pollution

The aircraft noise is a serious concern for the residents around the airports as well as under flight paths. Noise is not just annoying but higher noise levels damages health and can cause insomnia, mental disorders, stress, heart and blood circulation problems etc. It is an interference with school learning and academic achievement, it damages wildlife, it disturbs people from enjoying a simple peace and quiet atmosphere. Even if there has been an improvement in the aircraft noise performances during the past few years, the growth of aviation industry has outstripped these benefits. The significance of impact of noise depends on a variety of factors like duration, volume, time of the day, location and frequency of noise. The noise levels are measured using Decibel 'A' scale, which is usually expressed as dB (A). For an undisturbed sleep a limit of 55 dB (A) is considered as a standard limit. While the sound levels above 70 dB (A) makes normal speech communications impossible [3]. As with growing emissions, although the industry has been successful in developing quieter planes yet the noise footprints need attention and further reduction.

Effect on Air quality

Aviation is a major source of local air pollution. Aviation pollution is caused by CO_2 and other emissions from burning of aviation fuel (Jet-A Turbine aircraft) and Avgas (piston aircraft). This category also includes the GHG emissions from ground airport transport used by the passengers and staff to access the airport and the airport infrastructure development. The range of impact is high as jet emissions affect a 25 mile area around an airport in which humans, animals and plants are toxic crop dusted by them for 12 miles from a runway end. Local air quality also gets affected during the landing and take-off (LTO) cycle as these emissions are released below 3000 feet (915 metres) [4]. On the other hand a typical aircraft spews almost hundreds of tons of toxic and other pollutants into our atmosphere everyday thus depleting the ozone layer. Thus the contaminants emitted by the aircrafts and airport sources are harmful for the humans as well as the environment. Jet emissions cause serious implications on public health as it leads to lung, throat, nasal, asthma, larynx and brain cancer, leukaemia, lymphoma, and birth defects. A by product of jet fuel combustion known as benzpyrene when attached to soot, can cause cancer and tumours in humans. The impact of these pollutants on human health can be summarised Table 1 given by ICAO:

Water quality

The aviation and airports and airport development affect the water quality in several ways. Water at the airports is primarily consumed for airport and vehicle washing, catering facilities, and house in-house requirements such as drinking water, toilets and laundries. During expansions of the airports many tend to discharge the pollutants to nearby water sources. Also the airports create a range of potential pollutants including de-icing agents, painting and maintenance chemicals, testing of fie equipments, fuel leakages spillage from refuelling and storage. These are either leached out in the ground or contaminate storm water run off which can further pollute nearby water sources. On a less local level, the dumping of fuel from flying aircrafts can also cause water pollution by kerosene. It has been estimated that up to 15 million pounds of fuel were released over the worlds ocean by commercial and military aircrafts during the 1990s (Aerospaceweb, 2005) [5].

Affect on Land and visual impacts

The landscape is highly affected by the airports and airport development as it removes the existing landscape feature such as trees, hedges and replacing them with buildings and tarmac. Therefore it hampers the geology, landform, drainage, soil, ecology of that particular area. Also during the night, the lights of the runways, aircrafts and terminals increase light pollution. These impacts are equally important like other impacts of aviation and proper mitigation measures should be taken.

Climate Change and Global Warming

The green house gases released from aviation and which perturb Earths radiative balance are CO_2, H_2,

O, NO_x, SO_x and soot resulting in direct warming or cooling effects leading to Climate change and global warming. These gases also result in indirect effects such as contrail formation or aviation induced cirrus clouds, modifications in methane and ozone chemistry. On current trends, global average temperatures will rise by 2-3 degree C within the next 50 years. (Stern, 2006). Aviation generates Green house gases (GHG) in three main ways: (a) The largest source is the aircrafts as they emit large quantities of CO_2 and NO_x particularly during LTO (landing and take off). NO_x emissions in the atmosphere either increases ozone concentrations or decreases the methane concentration leading to global warming and cooling respectively occurring in different regions and altitudes. On the other hand, water vapour from combustion leads to the formation of contrails which further cause additional cirrus cloud formation. (b) The second largest source is the Ground traffic which includes travelling to and from the airport, and around the airport generating CO2. (c) Then is the airport infrastructure that requires electricity and heating. Airport construction also generates CO_2. The energy production generates the greenhouse gases and thus adding to the cause.

Thus the overall climate change effect of all aircrafts is roughly 2-4 times the effect of CO_2 alone. However the modern aircraft generate fewer CO_2 emissions per passenger km than the older ones. Improvements are further being made to reduce emissions from aviation in airport master plans and environment statements. Mitigation measures are usually aimed at reducing air emissions and improving the ground transportation rather than directly targeting climate change as an issue of its own. For all this there is an urgent need for developing a sustainable aviation strategy that would focus on the reduction of emissions from aviation and leading to the sustainable development of the environment.

SUSTAINABLE DEVELOPMENT

Mitigating aviations environmental impact: an approach towards sustainable air transportation

Sustainability is the way forward for aviation, as an industry which aspires to be safe, efficient, affordable, responsive and healthy. Underlying such purposes, the central role of EIA is emphasised i.e it acts as one of the instruments to be used to achieve sustainable development- development that does not cost the earth! Aviation has an impact on environment due to both carbon dioxide and non carbon dioxide emissions. As a step towards mitigating the global harmful effect of aviations growing impact upon the environment, there are various proactive technological measure adopted like:

Sustainable Biofuels

Fuels derived from plants and waste materials are called bio fuels. Plant derived biofuels however offer large savings in CO_2 emissions and thus also help in reducing the carbon footprints of aviation fuel by up to 80% over their full lifecycle. The sustainable biofuels are a cleaner source of fuels which can help billions of people who travel by air to lower the impact of their journey on our planet. Aviation biofuels are sustainable, cleaner, practical, viable, and essential [6]. There are several airlines that have operated biofuel test flights. The Virgin Atlantic airways conducted the very first biofuel test flight in 2008 between London and Amsterdam. It used a 20 percent blend of coconut oil with the traditional jet fuel. After that Air New Zealand in 2008 used jatropha, Continental Airlines (2009) used algae and jatropha as parts of biofuels. After a technical review biofuel was approved for commercial use in July 2011[7]. In India, Indian oil conducted test flights in march 2012. Indian oil that is a state running corporation has signed pacts with Canadian universities and Pratt and Whitney to further pursue bio-avjets like other countries. British Airways with Solena formed a partnership in 2009 and have worked to develop a unique project for London. According to it, from 2014 it is going to turn half a million tonnes of waste that normally goes to landfill from London city into biofuel to be used by the British Airways fleet. Biofuel derived from waste produces almost 95 percent less pollution therefore this measure will reduce emissions by the equivalent of 42,000 cars off the road per year [7] . According to ATAG report [8].In order for the aviation industry to reach its target of 1.5% average fleet fuel efficiency improvement per annum from 2010 until 2020, the world's airlines will have to purchase 12,000 new aircraft at a cost of $1.3 trillion. Since 2005, IATA's Green Teams have saved some 39 million tonnes of CO2 by advising airlines on fuel efficiency methods.

Sustainable aviation Biofuel not only brings environmental benefits for aviation but it can also foster the development of a new industry. Thus a new energy industry can be formed ranging from large quantities of Jatropha,Halophyts or camelina in the most appropriate environment, to establishment of algae farms on land, to smaller scale biofuel facilities in cities utilising municipal waste. However the focus of the industry is on finding sustainable biofuels that do not compete with food and are renewable.

Aircraft efficiency

Aircraft efficiency technologies reduce the amount of fuel an aircraft uses to travel per unit of distance. It is considered to be the most obvious and economical way of reducing the direct fuel burn of an aircraft. Several other technological improvements to improve

aircraft aerodynamics include application of laminar control to an aircraft to reduce drag and ultimately fuel consumption [9]. Other innovations include Blended wing body aircrafts that not only reduce drag but also allows the aircraft to generate lift, as opposed just to the wings [10]. Further more fuel efficient engines and inclusion of super lightweight materials into airframe improves aircraft efficiency. The next generation of aircrafts like the Boeing 787Dreamliner, Airbus A350 and Bombardier C series are expected to be 20 percent more fuel efficient per passenger kilometre than the current aircrafts.

Air Route optimization

The air traffic corridors that airplanes are forced to follow, effects aircrafts route forcing higher fuel burn and thereafter, an increase in emission. According to the New York Times [11], an improved Air Traffic Management system with more direct routes and optimised cruising altitudes shall allow airlines to reduce their emissions by 18percent. 1,715 airlines operate a fleet of 23,000 aircraft serving 3,750 airports through a route network of several million kms managed by 192 air navigation service providers [12].

Emission trading schemes

Under article 17 the Kyoto protocol, one Annex B country will be allowed to purchase the rights to emit greenhouse gases from other Annex B countries that are able to cut greenhouse gas emissions below their assigned amounts. Although Annex B to the Kyoto Protocol and Annex I to the Convention are now identical in nature, this change from Annex I into Annex B potentially allows a developing country to engage in emissions trading if it voluntarily adopts an emissions target and is inscribed in Annex B. The market-based emissions trading approach can only achieve significant cost reductions in cutting greenhouse gas emissions while also allowing flexibility for reaching compliance if it is structured effectively. There are various active trading programs. For Greenhouse gases the largest is the European Union emission trading scheme, whose main aim is to avoid climate change.

Aircraft Noise abatement

One of the most serious and important issue is the aircrafts noise which is being dealt with many different methods. ICAO [13] has noise abatement procedures in Annex 16, Volume I, Part V and procedures. Noise abatement procedures help in reduction of noise during aircraft operations. Various measures such as improved operating procedures and land-use planning and management techniques are an effective means to ensure reduction in noise levels. Land use planning specifically focuses on the introduction of land use zoning around airports to minimize the population affected by aircrafts noise. ICAO's Annex 16, Volume I, Part IV and the airport planning manual, part 2 (DOC (184) has details on this subject.

Green initiatives for infrastructural advancements

Adopting land use planning and technological features such as good design of buildings, adoption of green initiatives, careful use of colour for furniture, minimizing light pollution by keeping lighting of keeping lighting (e.g. of parking lots) to the minimum levels needed for safety, and through the careful choice of light fixtures such as the use of flat-glass lanterns in car parks. Some buildings, particularly airport terminals, can be very attractive, and many people prefer the aesthetics of a well-designed and well-managed development to those of derelict, scrubby areas. In such cases, the development is a visual improvement. Other measures may include landscape engineering, tree planting etc.

Improved Operating Procedures

Along with technological advancements, changes in the operating procedures can also reduce the impact of noise and emissions. In this both pre-flight and in-flight procedures need attention. Pre flight procedures like minimising the aircraft load factors, distributing the weight of passengers to achieve fuel efficient centre of gravity, minimizing the take off weight. Whereas in-flight procedures like flying at the most efficient route, use of continuous descent approach (CDA) to reduce both fuel burn and noise beneath the approach pathway, flying as close to the most fuel efficient speed, wind and altitude, using one engine to taxi wherever possible, close monitoring of fuel efficiency of every aircraft. With the recommendations of these improved operating procedures almost 10 kg to 15kg of fuel savings per flight and 60 to 100 tons of CO_2 savings per year per aircraft can be easily generated [14].

Reducing the impact of Non Co_2 emissions

Apart from CO_2, aviation emits a number of other pollutants like Nitrous oxide, unburned hydrocarbon (UHC), particulates and contrails. NO_x is produced in small quantities from aircraft engines are more harmful than CO_2. Similar is the case with the particulates and smoke and unburned hydrocarbon which is a result of incomplete combustion. All these however can be managed and eliminated though new modern engine designs.

Table 1: Representative Health Effects from Local Air Quality Pollutants

Pollutant	Health Effect
CO – Carbon Monoxide	• Cardiovascular effects, especially in those persons with heart conditions
HC – Unburned Hydrocarbons (a primary component of Volatile Organic Compounds, or VOC)	• Eye and respiratory tract infection • Headaches • Dizziness • Visual disorders • Memory impairment
NO_x – Nitrogen Oxides	• Lung irritation • Lower resistance to respiratory infections
O_3 – Ozone (HC is a precursor for ground-level O_3 formation)	• Lung function impairment • Effects on exercise performance • Increased airway responsiveness • Increased susceptibility to respiratory infection • Increased hospital admissions and emergency room visits • Pulmonary inflammation, lung structure damage
PM – Particulate Matter (smoke is a primary component of PM.)	• Premature mortality • Aggravation of respiratory and cardiovascular disease • Changes in lung function • Increased respiratory symptoms • Changes to lung tissues and structure • Altered respiratory defence mechanisms

Source: ICAO 2010, Environment Report 2010.

Table 2: Greenhouse Gas Emissions by the Aviation Sector in 2007 (thousand tonnes)

Greenhouse Gases	Emissions
CO_2	10,122.00
CH_4	0.10
N_20	0.28
CO_2 equivalent	10,210.90

Source: Ministry of Environment and Forests.

Table 3: Permissible Noise level at DIAL

Airport Zone	Limits dB(A)	
	Day Time	Night Time
Industrial Area	105	95
Daytime	From 0600 hrs to 2200 hrs	
Night time	From 2200 hrs to 0600hrs	

Source: Directorate General of Civil Aviation

Carbon offset

Carbon offset is a means of reducing emissions to zero level by saving enough carbon to balance the carbon emitted. Thus it is an action by airline passengers and corporate customers to neutralize or compensate for greenhouse gas emissions, arising from their use of commercial aviation at least in the short term. Many airlines have begun offering carbon offsets to passengers. The money generated out of this is used to invest in green and renewable technologies worldwide. Some of the airlines offering carbon offsets are Continental Airlines, delta Airlines, British airways, Lufthansa, Quantas etc.

Policies, environmental standards and Market based measures

If the adverse environmental effects of aviation are to be averted, the government needs to develop and implement appropriate policies, programs and mechanisms and accelerate their integration into the complete aviation system. There are certain means by which the government can address the issue of sustainability for the aviation industry like moderating the demand through emission charging, fully optimising the use of current existing airport capacity, encouraging and incorporating the sector into open emission trading schemes etc. Cooperative partnerships can further focus and leverage funding that would be beneficial for both aviation and environment. International Civil Aviation Organization (ICAO) has made efforts in limiting and reducing international aviation emissions, including development of a CO2 standard for aircraft, and a new particulate matter (PM) certification requirement for engines. It has also agreed to explore more ambitious goals for the aviation sector, including carbon neutral growth in the mid-term and reductions in the long term. Thus, in order to achieve environmental and energy goals, it is a major responsibility and requires harmonization with international standards in developing policies that may be needed to accelerate the integration of new technologies into the civil fleet compared to the normal rate of introduction and replacement.

Improving the environmental effects of aviation is a challenge and all such measures and discussions are necessary for its abatement for the sustainable development of future of flights.

India's Perspective: A case study of Indian aviation on sustainability

As mentioned earlier, the transportation sector of any country plays an integral part in the growth and development of an economy. The potential for the aviation sector is thus immense as India is a huge country with a great diversity. The Indian aviation industry completed its 100 years in 2011dipicting a tremendous growth rate in the last few years and making it the fastest growing transportation mode. According to the Indian Aerospace Industry Analysis report [15] at present India stands at the ninth position in the world in terms of passenger traffic with about 150 million passengers passing through the airports. And if this trend continues the traffic at Indian airports is expected to reach 450 million by 2020, with some 90 million passengers per annum (mppa) projected to pass through Delhi alone and thus making India the third largest aviation market in the world. It currently has 134 airports, of which about 34 airports are non operational. It has 17 international and 81 domestic airports [16].

Aviation fuels

Two major aviation fuels are Aviation Turbine Fuel (ATF, also called as Jet fuel) and Avgas (Aviation Gasoline). The most common fuel for commercial aviation ate kerosene based Jet A and Jet A-1. Most Indian aircrafts use Jet A-1.

Regulatory framework

International: International Civil Aviation organisation (ICAO) is a specialized United Nations agency founded in 1944 and currently has 190 contracting states. Its mission is to 'set standards and recommended practices for the safe and orderly development of the international civil aviation'.

India: The ministry of civil aviation is responsible for policy formulations and programmes, development and regulation of civil aviation. The Directorate General of Civil Aviation (DCGA) under the ministry of civil aviation is the regulatory body in India. In accordance with ICAO annex 16, DGCA sees its responsibility in "keeping a check on aircraft noise and engine emissions" [17].

Existing emission norms for aircraft operations

In 1981 in order to control local air quality, the ICAO adopted international emissions standard for HC (unburned hydrocarbon), CO(carbon monoxide), NOx (oxides of nitrogen) and smoke form jet engines. The emission standard for NOx has been made 50% more stringent relative to the adoption level in 1981 and will be tightened further by 15% for newly produced large engines effective on December 31, 2013 [18]. These standards are delineated in Annexx 16 to the convention on International Aviation Annex 16 consisting of Volume I and II, which deals with aircraft noise and engine emissions respectively.

Impact Assessment

Although India's aviation market significantly contributes to the development of the country with a tremendous growth rate, it inevitably also leads to

huge environmental challenges. The Directorate general of Civil Aviation (DGCA) which is the Indian governmental regulatory body responsible for implementing, controlling and supervising airworthiness standards, safety operation, crew training etc in India, in October 2012 issued its first-ever annual report on the carbon footprints of its aviation industry in line with India's initiative to address the climate change challenge. The report also has a strategy of developing a sustainable aviation framework for the country's aviation sector.

According to the report [19] (a) a combined study of Indian domestic and international scheduled airline operations show that12.7 million tonnes of CO_2 were emitted in 2011, a 6 percent increase in comparison with 2010. Based on the local fuel uplift, the foreign airlines serving international destinations from Indian airports emitted 3.6 tonnes of CO_2 last year. (b) The CO_2 emissions from Indian scheduled airline operations as well as foreign airlines to international destinations represent less than 1 percent of the country's total CO_2 emissions. This number is slightly lower than the global average contributions of airlines, which represent 2 percent of global anthropogenic emissions. (c) The report also concedes that in the business-as-usual scenario (i.e., no measures taken to reduce emissions), emissions of Indian scheduled airlines from domestic and international operations should reach 27 million tonnes by 2020, and 209 million tonnes by 2050. (d) It also states that emissions from operations at Indian airports are much less than airline emissions and are estimated at approximately 700,000 tonnes in 2011, representing just over 5 percent of the total aviation emissions.

Apart from all this, airport infrastructure development also leads to adverse effects on the environment. It is mandatory for any airport project to obtain a clearance before initiating any construction work.

Here are a few steps and details of the environmental management of certain projects taken in India.

The Carbon footprints of India

According to the United Nations Intergovernmental Panel on Climate Change, global CO_2 is currently only 2 percent and its here from all transport sources is only 12 percent. As per the latest data available, in 2001, the transport sector in India emitted 142.04 mt of CO_2 equivalent amongst which aviation sector was the second largest contributor with 10.21 mt of CO_2 after roads [20]. The green house gas emissions from the aviation sector in 2007 are shown in Table 2

India is a member state of ICAO and it equally implements the resolutions on environmental policies and practices adopted by ICAO through its primary regulatory authority for the sector; Directorate General of Civil Aviation (DGCA). With an increased and speedy growing aviation sector and its escalating threat on environment, the DGCA established an environmental unit in 2009 to look after this issue. The unit is designed for various stakeholders to reduce carbon footprints through practicable and economic means. As India is exempted from Kyoto Protocol, it has no set targets for emission reductions. Yet the DGCA on its level tries to reduce as much as it can. The DGCA has also advised all aerodrome operators, aircraft navigation service providers and all airline operators to set up aviation cells to reduce emissions.

Environmental management

Noise level

The Ministry of Environment and Forest has classified noise levels primarily into four categories: Industrial area, commercial area, residential area and silence area. The airports however fall under the industrial category under which the limits vary from 75 dB(A) during day time to 70 dB(A) during the night time. The noise levels however vary. The busiest airports across the world thus have a separate area known as the 'Airport Vicinity Zone' where the ambient noise levels are expected to be much higher than other categories. According to the ICAO's mandate on minimising the noise level of aircrafts, the DGCA has been implementing a number of noise abatement measures along with plans of recording data for a comparative analysis of other similar airports. One such example is at the IGIA- Indira Gandhi International Airport, Delhi measures such as use of continuous descent approach procedures during landing, mix mode operation system from three runways at the airport to distribute noise concentration over a larger area, and restricting aircraft movements between 2200 hrs and 0600hrs have been taking place. Table 3 shows the permissible noise level at DIAL-Delhi International Airport Limited (DIAL).

The DIAL is also in the process of establishing an aircraft noise monitoring system to develop a database of aircraft noise. Even the Hyderabad International Airport (HIAL) conducts noise monitoring at 10 locations at the airport and nearby areas. In which the results were generally found to lie within the range prescribed by the CPCB (Central Pollution Control Board).

Air Quality

Noise is considered to be the primary environmental constraint on airport operations yet local air quality is another concern. In India the CPCB has prescribed the National Ambient air quality standards for residential areas. Air quality monitoring is done at the

airports for parameters such as SPM, SO_2, NO_X, Hydrocarbon Carbon (HC) and CO. According to the Airport Development report 2011[20] the DIAL regularly monitors air quality a five locations inside the airport and two outside the airport. It has also initiated various emission reduction activities. Similarly HIAL (Hyderabad) monitors its indoor air quality on a real-time-basis. It is seen that the differential CO_2 levels at any time are maintained below 530 parts per millions.

Water Quality

The water requirements at most of the airports are managed through groundwater sources. At the Delhi airport, DIAL has installed 300 rain water harvesting systems (RWH). It also has a sewage treatment plant to treat waste water which can further be used for fire fighting, meeting landscaping, cooling plants, air conditioners, flushing requirements etc. Similarly HIAL has also installed RWH systems.

Waste Management

Dial has entered into various agreements with waste management companies wherein all the waste generated at Terminal 3 T (3) will be utilised to produce electricity. There has also been a set up of municipal solid waste processing complex to generate electricity from the household garbage from landfill site of Ghazipur. This is a joint venture of GMR energy, one of DIAL's major holding companies with Selco international. About 10 MW of electricity would be generated from this plant. Under the Leadership in Energy and Environmental Design (LEED) DIAL has taken the green initiative for certification of T3 the Green Building Project is an initiative of increasing the efficiency with which a building uses resources like energy, water etc while reducing the impact on human health and environment. The Hyderabad airport building was the first in Asia that received the LEED New construction Silver rating by the US green building council. Almost 25 percent savings in energy and 30 percent savings in water usage have been noted due to the green initiatives at the Hyderabad airport.

Issues and concerns in the Indian aviation sector

Inspite of the environmental management being taken up by the DGCA, there are a lot of aspects that need our attention in order to attain a sustainable model. At the ground level there are certain issues, as follows:

Poor environmental Governance: The lack of capacity to handle clearance and monitoring of projects by the central and state levels is a big concern. This can be seen from the fact that only nine states at present have an environmental department. Another issue is the delay in processes due to multiple levels of clearances from local and state levels to central levels. Also the delay in receiving environmental clearances is because of inadequate number of EACs and the lack of staff. Monitoring is equally poor and enforcement is not strong enough and is mostly done through a command and control regime.

Lack of environmental impact assessment at the Sectoral level: At present the environmental impact assessment is evaluated on a project by project basis which needs to be preceded by an environment impact assessment at the sectoral level.

Review of resource maps with improved access to them: There is an urgent need for the revision and assessment of resource maps relating to minerals, fuels, forests, water etc. Apart from revision, accessibility of these maps to the developers should be made transparent and easier. Also these resource maps should be updated at regular intervals.

Lack of easy and public access to environmental compliance reports: Due to the multiple layers of bureaucracy, access to the compliance reports that the developers have to submit in every 6months is next to impossible. To resolve this issue, an online database of these documents is an immediate requirement.

Larger participation of Developers: On the developer's front, there is a general perception that it is the responsibility of the government to manage the environmental aspects in any infrastructure development. In this regard, due to the lack of responsibility and accountability on developer's part has further deteriorated the environment. Therefore regular environmental audits and proper monitoring of projects should be ensured and the reports should be made public.

India towards Sustainability

India is however becoming more aware of this global concern and has taken major steps in the field of aviation and climate change. Transportation which promotes sustainable development and also preserves our environment has become increasingly important. Under the Ministry of Environment and Forests, all organisations are given instructions to make every effort to protect the environment and also adopt global environment standards. The environment management has been taken up largely by the DGCA. Several airports specifically those in the planning stage or under implementation have made efforts in synchronising with environmental concerns. The Airport Authority of India (AAI) has undertaken various sustainable development projects across different airports in the country. At the airports various sustaible development works like sewage treatment plants at Indore, Lucknow, Rajamundry and Ahmadabad airports have been installed.

Similarly water management with RWH plants at Indore, Luchnow, Jaisalmar, Ahmedabad airports. Energy management initiatives at Rajiv Gandhi Bhawan, Delhi, Chandigarh etc have been undertaken like street lighting, LED type taxiway lighting system, energy conservation building etc.

Also according to the latest circular issued by DGCA on June 20 2013, the DGCA decided to enforce an aviation climate change taskforce with stakeholders to assess trends in carbon emissions, assist data collection and analysis. Initiatives to minimize and curb emissions in the sky as well as the airports were another step taken by them. Apart from this it also directed to the airlines and airport operators with more than 50,000 movements per year to have an independent Aviation Environment cell in their organisation. The airlines are thus making improvements in this sector. This is clearly visible from the effective airline initiatives on fuel efficiency and fleet renewal, the participation of three airports (Mumbai, Delhi and Bangalore) in Airport Carbon Accreditation scheme. The accreditation had been given for three categories namely: mapping (level1), reduction (level2) and optimization (level 3). Mumbai, Delhi, Bangalore and Hyderabad airports were seen to be on the second level which means all these airports have moved from mapping its carbon footprints to taking actions to reduce it. Also with the establishment of the very first 'Carbon footprint of Indian Aviation 2011' report by the DGCA, India too is taking its foot forward towards minimizing this global concern.

CONCLUSION

The aviation sector is considered to be the safest and the most efficient of all other modes of transportation. However the reliability on aviation and the environmental impact are becoming critical issues for the future of flights. This high premium of safety demands the incorporation of proven and technically sound technologies, policies and practices which aim at reducing the environmental impacts. All the efforts need prime focus and interdependent set of technologies and operations need to be adopted so that actions to reduce impacts in one area can also impact the other areas. In order to reduce the harmful effects of emissions on our environment, there is a pressing need to develop a focussed and sustainable aviation strategy which would be an outcome of extensive research and development, implantation of technological, operational and policy initiatives that would address mobility and the environmental needs. Aviation's impressive record of creativity and innovation can rise to these challenges and help us in attaining sustainable aviation for the society- aviation that meets the needs of society for air travel and transport, while removing or minimising any negative impacts on the local and global environment and thus maximising its contribution to the economy.

Thus to conclude, 'technology creates crises and only technology can help in overcoming them'.

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