UPES Centre for Continuing Education

Environmental Impact of Aviation.

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A DISSERTATION REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

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OF

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Finally, I humbly extend my sincere gratitude to all my friends and family who show their care and constantly motivate me to work hard and improve myself.

Signature

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A Declaration by the Guide

This is to certify that the Mr Allan Dilip Patil, a student of MBA in Aviation Management, SAP ID 500063768 of UPES has successfully completed this dissertation report on "Environmental Impact of Aviation" under my supervision.

Further, I certify that the work is based on the investigation made, data collected and analysed by him and it has not been submitted in any other University or Institution for award of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfilment for the award of degree of MBA.

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Place – Mumbai
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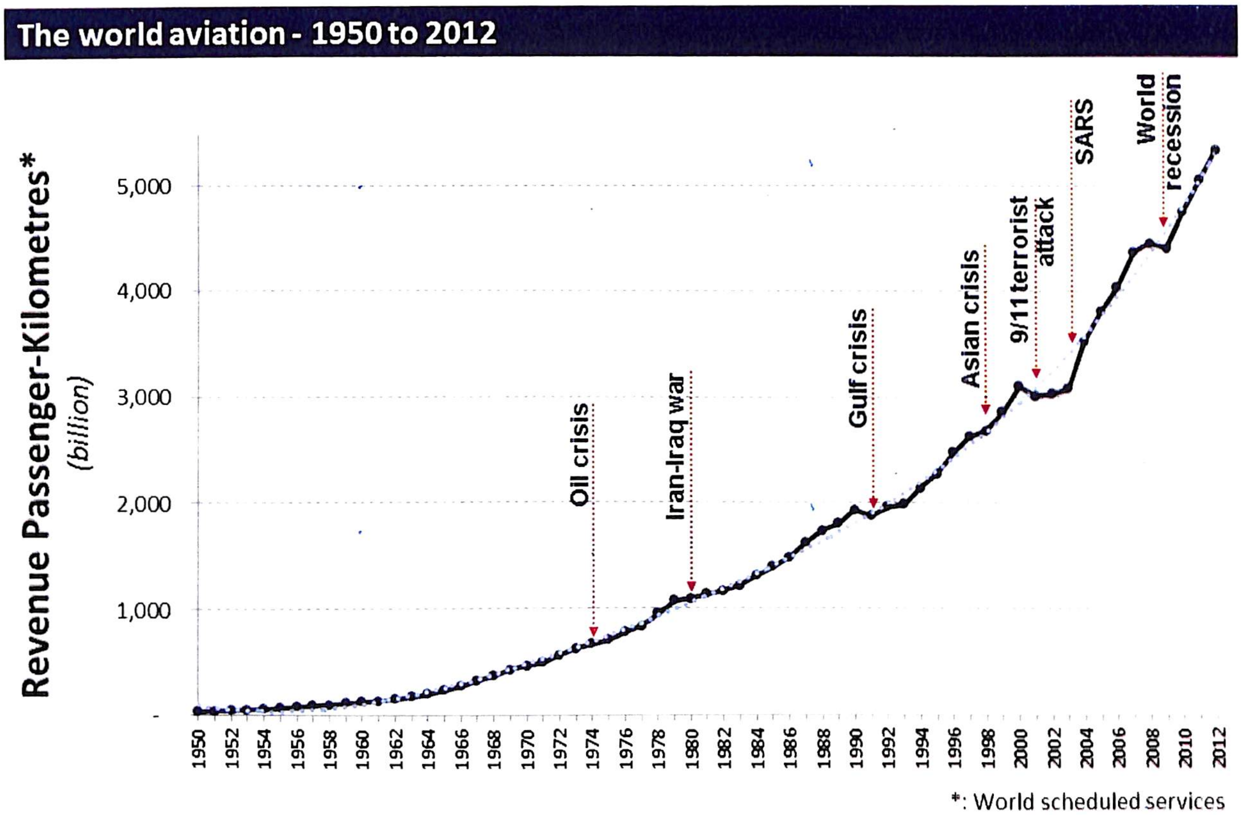

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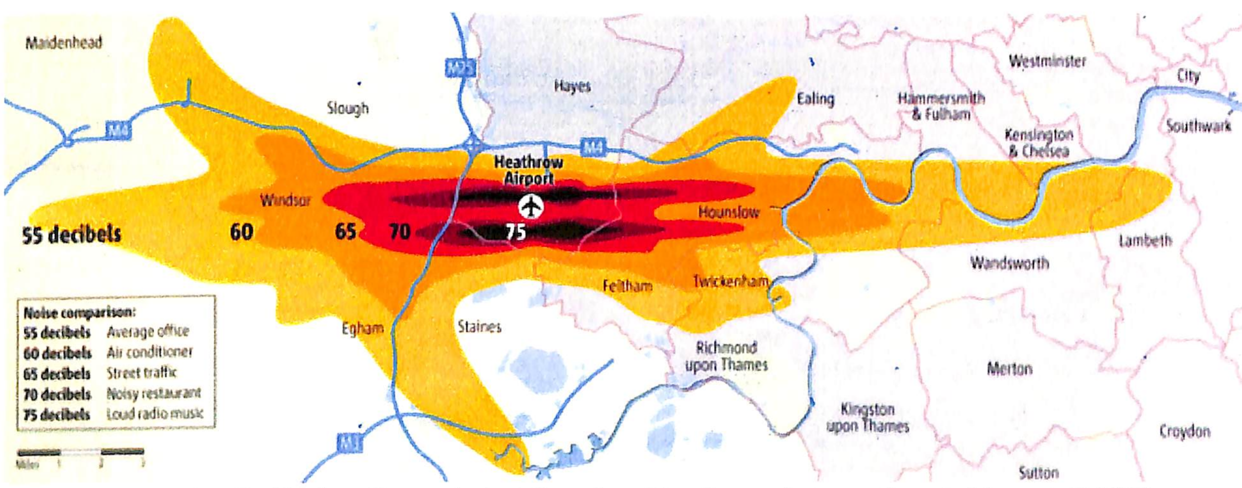

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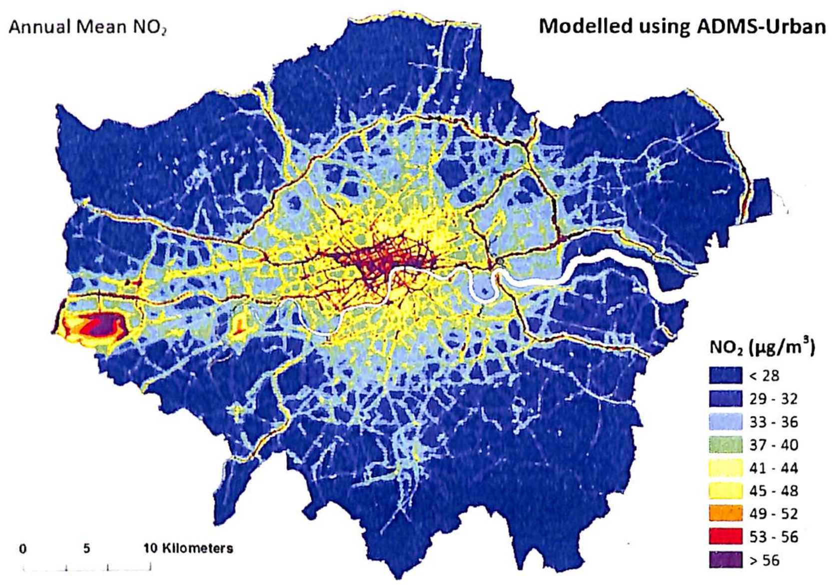
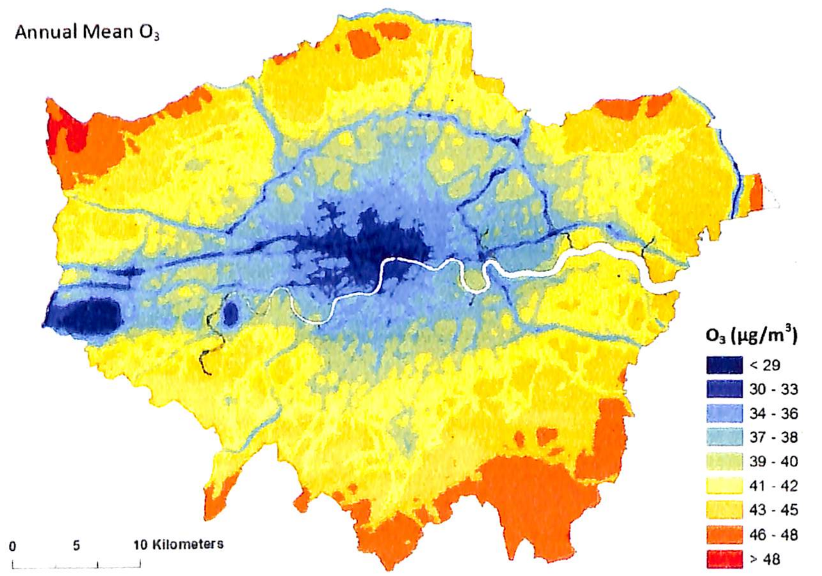
Single Noise Event in Dwelling	45

Source: WHO 1993





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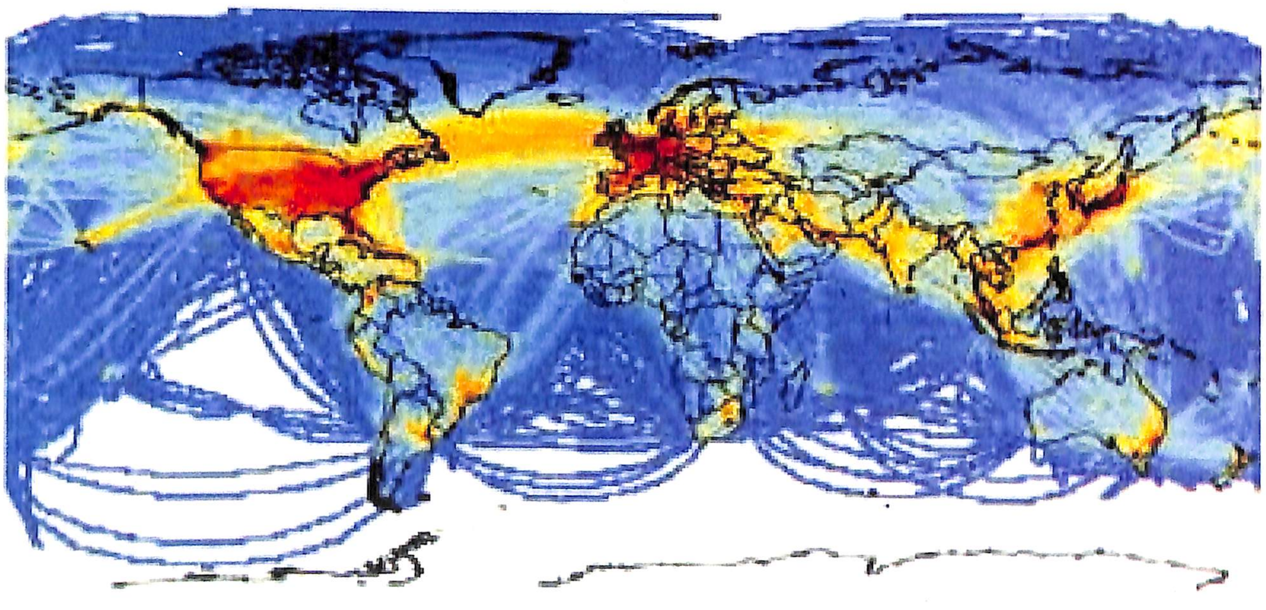

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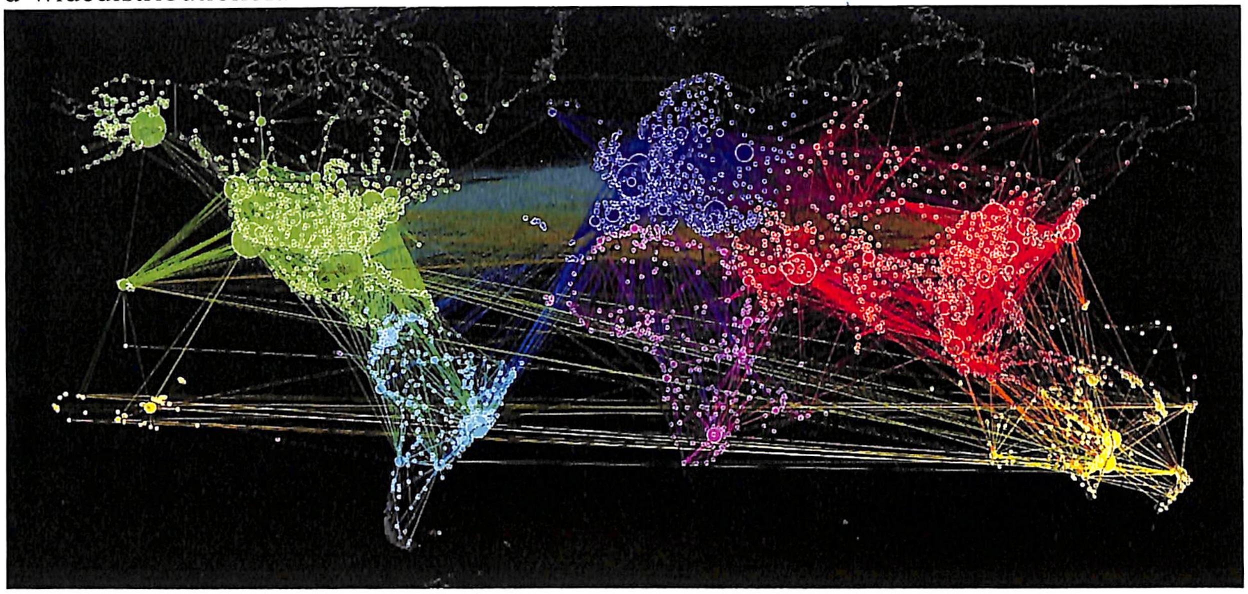

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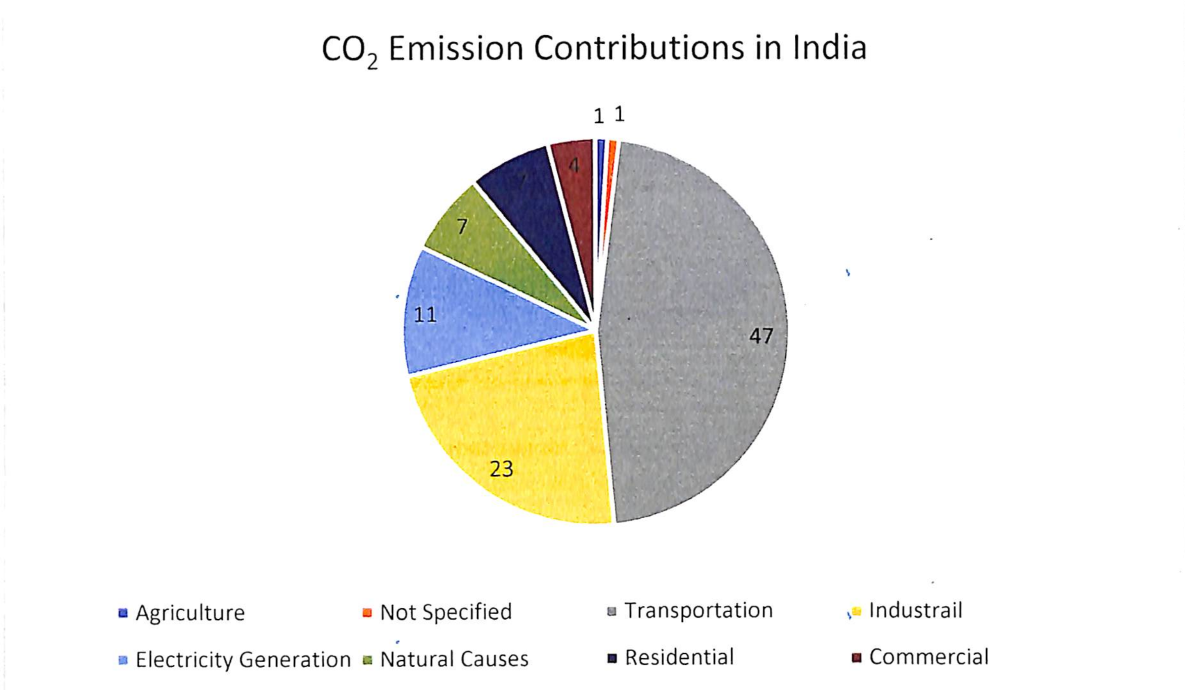
Qualitative research	Quantitative Research
The aim is a complete, detailed description.	The aim is to classify features, count them, and construct statistical models in an attempt to explain what is observed.
Researcher may only know roughly in advance what he/she is looking for.	Researcher knows clearly in advance what he/she is looking for.
Recommended during earlier phases of research projects.	Recommended during latter phases of research projects.
The design emerges as the study unfolds.	All aspects of the study are carefully designed before data is collected.
Researcher is the data gathering instrument.	Researcher uses tools, such as questionnaires or equipment to collect numerical data.
Data is in the form of words, pictures or objects.	Data is in the form of numbers and statistics.
Subjective – individuals' interpretation of events is important., uses participant observation, in-depth interviews etc.	Objective: seeks precise measurement & analysis of target concepts, e.g., uses surveys, questionnaires etc.
Qualitative data is 'richer', time consuming, and less able to be generalized.	Quantitative data is more efficient, able to test hypotheses, but may miss contextual detail.

Researcher tends to become subjectively immersed in the subject matter.	Researcher tends to remain objectively separated from the subject matter.



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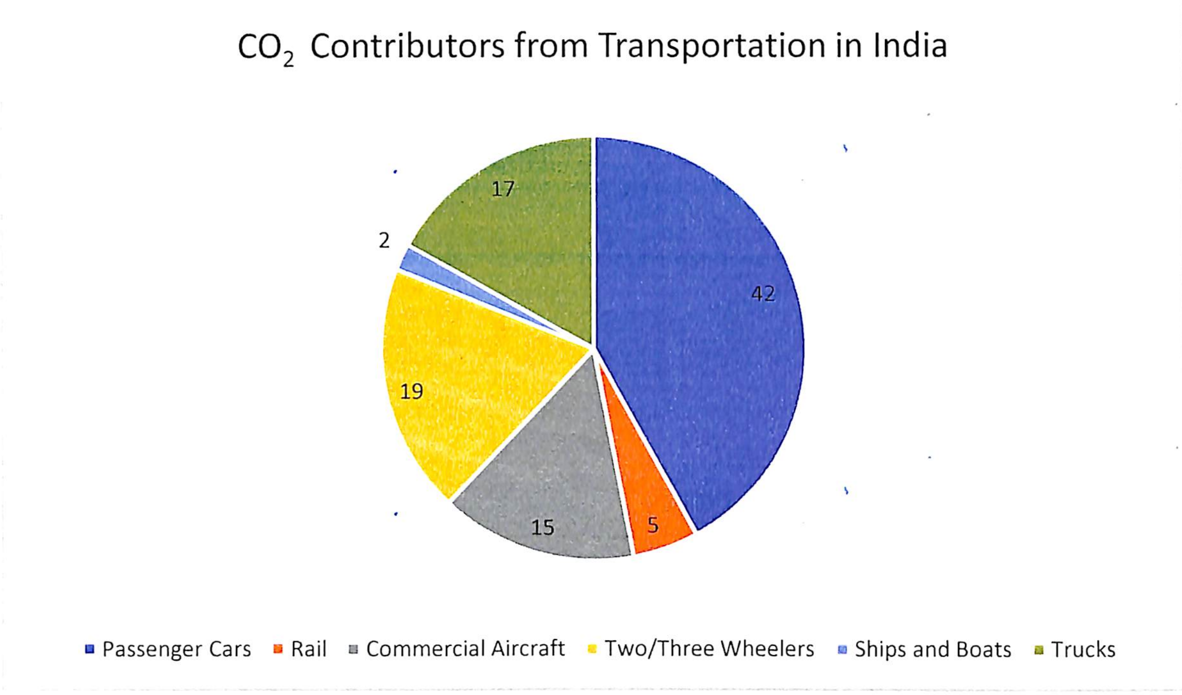

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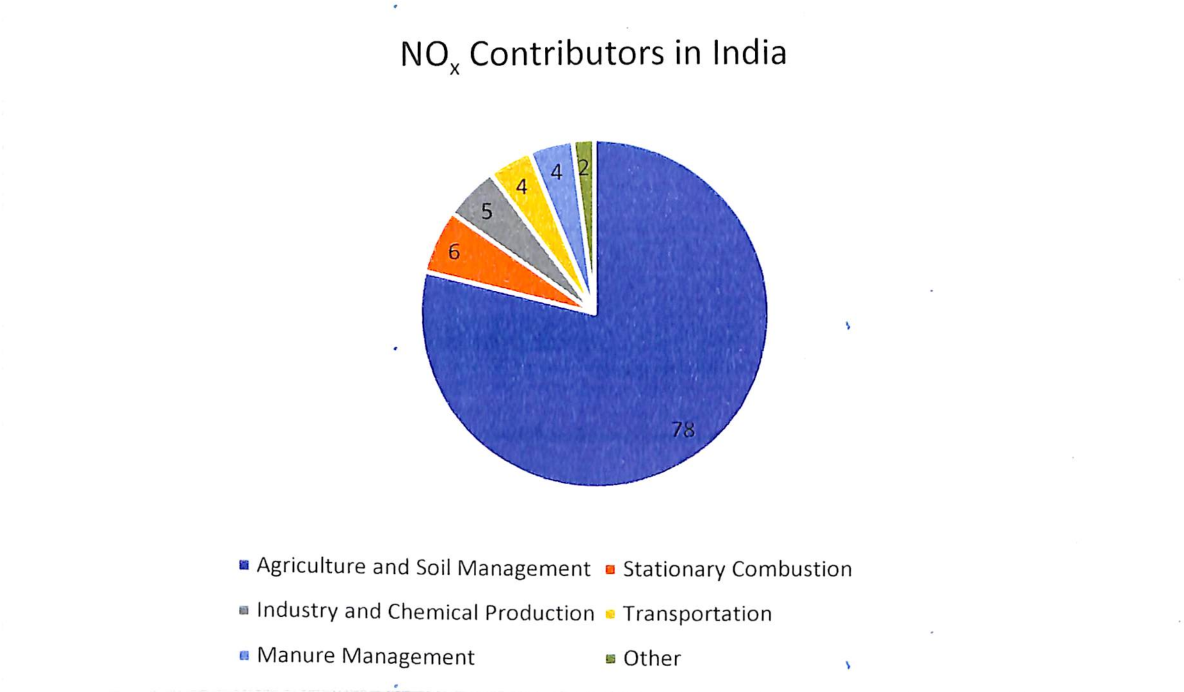

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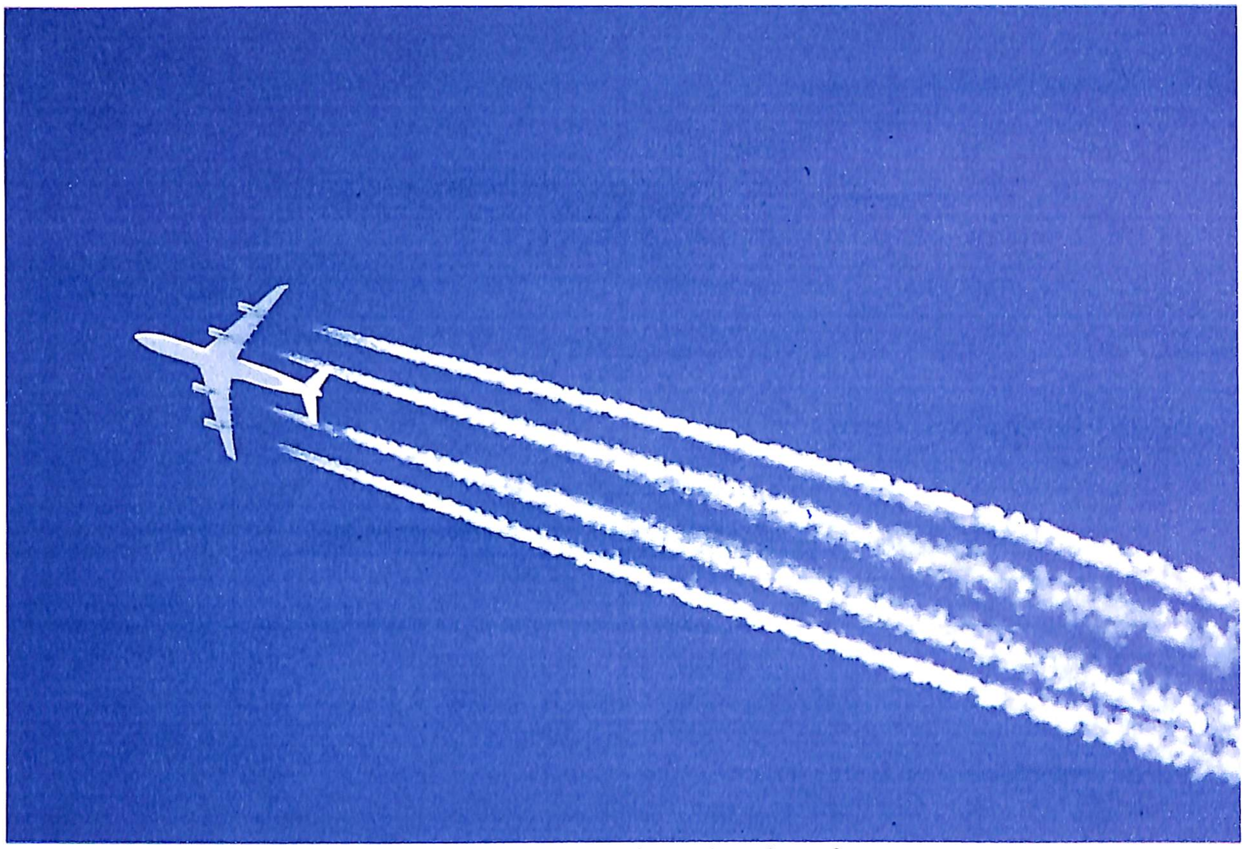
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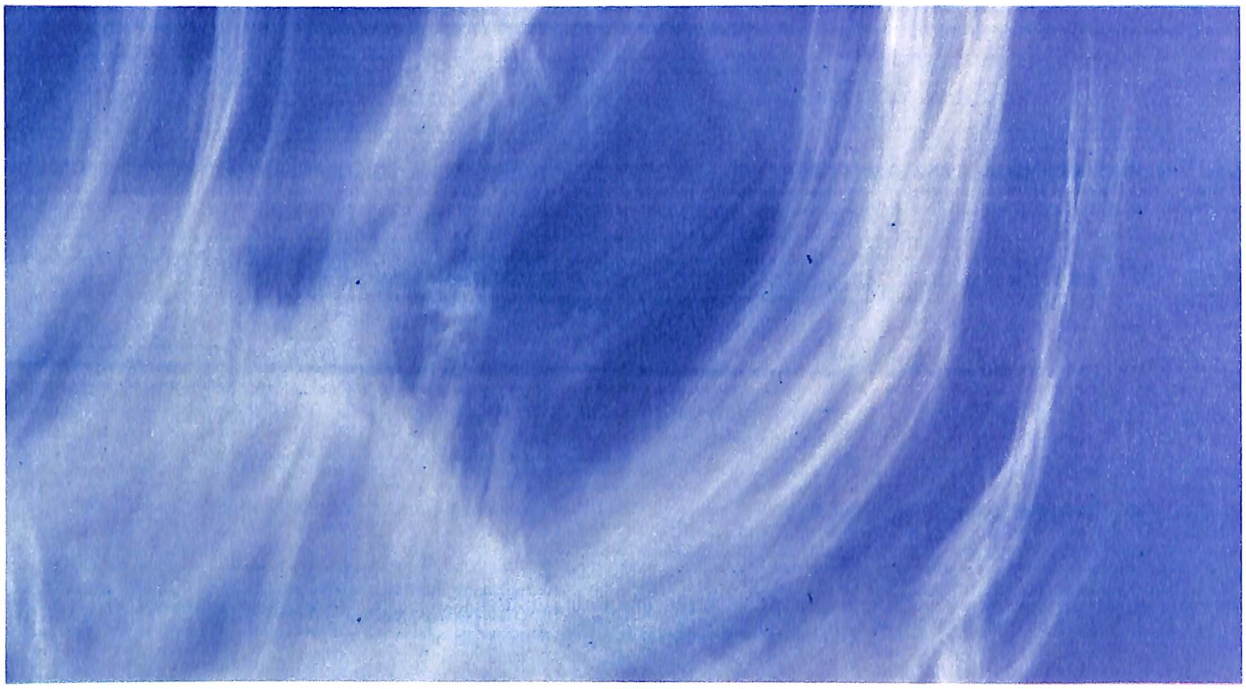

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Abstract

Aviation demonstrates very strong growth rates. Forecasts of this growth are described and reviewed. On a 1995 base global forecasts of miles flown in the year 2015 range from a low growth of 181% to a high growth of 380%. In India where forecasts are made of terminal passenger numbers the latest government forecasts predict a 239% change on 1995 by 2015.

Aviation is one of the fastest growing industries worldwide and the fastest growing transportation mode in India. Air transport brings substantial social and economic benefits and underpins the global economy, but it also has a local and global impact on the environment. For nearly five decades air transport has provided significant public benefits. It has brought work, prosperity, increased trade and new travel and tourism opportunities under the concept of liberalization, privatisation and globalization. Air transport is now a massive and economically vital business, encompassing the manufacturers and operators of engines and aircraft, fuel suppliers, airports and air traffic control systems.

The relative importance of environmental issues in aviation sector has grown considerably as has the complexity and evolving nature of environmental problems associated with aviation. Airlines and Airports are interlinked and form a strong mesh that encompasses all critical aspects relating to climate and environment. At the outset, this Research focuses on the growth in India's air traffic; classification of and causes of environmental issues in aviation industry; its impact on public health and environment; the scientific consensus on its environmental impacts, promising emission mitigation measures; how to overcome or minimize the impact of aviation on climate change taking into consideration the present legal framework in curbing the said environmental issues pertaining to aviation sector in India.

Chapter 1

1.0 Introduction.

Aviation is a fast-growing sector of the economy. It is associated with several social and economic benefits and a range of environmentally damaging consequences. It is also associated with a significant and growing contribution to the global inventory of greenhouse gases which are thought to be implicated in climate change. This report sets out to provide a clear basis of evidence for a wider and deeper public debate on these issues and concludes with a number of policy recommendations that are intended to ensure that aviation continues to contribute to the economy in a way that does not threaten environmental quality either globally or locally.

The debate about aviation and its strong growth trajectory is very poorly developed. There is an unquestioning acceptance in government that the rising demand for air travel will continue and that the land use planning implications (especially more terminals and runways) of this can be managed with minimal harm to the environment. The aviation industry has been very successful in its adoption of an environmental agenda (environmental reports, support of exotic, threatened environments, appointment of environmental managers, financial support for a professorship of "sustainable aviation") but has been less forthcoming on questions of growth and the need for reductions in greenhouse gases. The industry has benefited from a well-developed system of public support. Airports can expect to be linked at public expense by very expensive infrastructure to the motorway system. Equally the industry does become involved in direct funding of this infrastructure.Nevertheless, in the language of environmental economics aviation does not meet the full external costs generated by its own activities (noise and pollution) and fails to pay for direct costs generated by the activity itself.

This report is intended to raise levels of awareness about the growth of aviation and its environmental consequences. This is especially important in India. India is one of the most important aviation markets in Asia with the 13th biggest airline (Indigo, Capacity 75,670,054 Seats, Fleet 245), the 12th largest airport (Indira Gandhi International Airport), a very dynamic market (new low-budget airlines) and high passenger growth rates. Road based transport has recently emerged from a similar process of debate and reflection which has led to a greater understanding of the links between providing new roads and the growth in road traffic and the economic benefits of improved road access. A better understanding of both areas has resulted in a scaling down of new road construction. The time is now right for a similar process of reflection and debate for air transport.

The report is intended to stimulate a public and a policy debate around aviation and its growth. Government policy in transport has made great progress in recent years in its recognition of the importance of integration and in its espousal of demand side and supply solutions to transport problems. It is now time to extend these principles to aviation and through an informed debate to identify the main elements of a new approach to aviation in India, the South Asian Sub-Continent and globally. This approach should be firmly rooted in changes to Indian policies (the main target of this report) and through Indian policies into Asian and global debates where changes also need to be made if a coherent approach to aviation is to be achieved.

1.1 Overview

A study of ways to reduce aviation noise and emissions was mandated by the United States Congress in the Vision 100–Century of Aviation Reauthorization Act (H.R. 2115, Public Law 108-176, Section 321). Appendix A contains the full text of the relevant section of the legislation. The mandate asks for consideration of operational, infrastructure, and technological changes or improvements to mitigate the environmental effects of aviation. Based on the legislation language and consultations with FAA, NASA, the Aviation Subcommittee of the House Committee on Transportation and Infrastructure, and the Space and Aeronautics Subcommittee of the House Committee on Science, goals for this study were defined that are broader, but inclusive of the requirements of P.L. 108-176, Sec. 321. In particular, we sought: • to develop a shared vision of national goals for addressing aircraft noise and emissions • to develop actionable recommendations by consulting stakeholders and examining and learning from the results of past activities on aviation and the environment • to recommend a sustainable implementation plan to achieve the stated goals The study was conducted by the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER), an FAA/NASA/Transport Canada-sponsored Centre of Excellence (COE), on behalf of FAA and NASA, with participation from governmental organizations, academia, industry groups and community groups. We began the study by synthesizing key findings and themes from 35 prior studies. During the study it became apparent that significant opportunities for long-term environmental improvements exist beyond the domains of advanced technology and operations, through better interagency coordination, and through the development of more effective tools and metrics. Therefore, following the judgment of the study team and the participating stakeholders, we have placed less emphasis on a detailed review of advanced technological and operation opportunities than indicated in the language of the legislation.This document is the final report resulting from the study.

1.2 Background

This Purpose of Study is important to understand because aircraft engines emit heat, noise, particulates and gases which contribute to climate change and global dimming.Airplanes emit particles and gases such as carbon dioxide, water vapor, hydrocarbons, carbon monoxide, nitrogen oxides, sulphur, lead, and black carbon which interact among themselves and with the atmosphere.

Despite emission reductions from automobiles and more fuel-efficient and less polluting turbofan and turboprop engines, the rapid growth of air travel in the past years contributes to an increase in total pollution attributable to aviation. From 1992 to 2005, passenger kilometres increased 5.2 percent per year. In the European Union, greenhouse gas emissions from aviation increased by 87 percent between 1990 and 2006.

Comprehensive research shows that despite anticipated efficiency innovations to airframes, engines, aerodynamics and flight operations, there is no end in sight, even many decades out, to rapid growth in CO_2 emissions from air travel and air freight, due to projected continual growth in air travel. This is because international aviation emissions have escaped international regulation up to the ICAO triennial conference in October 2016 agreed on the CORSIA offset scheme.In addition, due to low or non-existent taxes on aviation fuel, air travel enjoys a competitive advantage over other transportation modes due to lowerfares. Unless market constraints are put in place, growth in aviation emissions will result in the sector's emissions amounting to all or nearly all of the annual global CO2 emissions budget by mid-century, if climate change is to be held to a temperature increase of 2 °C or less.

There is an ongoing debate about possible taxation of air travel and the inclusion of aviation in an emissions trading scheme, with a view to ensuring that the total external costs of aviation are taken into account.

1.3 Purpose of Study

There's no denying the positive economic and social impact that air transport has had on our global society. From making it convenient for us to travel to far-flung places and experience different cultures to enabling isolated communities to have a source of income from tourism, there have been tremendous benefits brought about by aviation. This sector is a major engine for growth—more than 10 million jobs are directly related to aviation.

That said, a natural question that begs to be asked is, "what effect is global aviation having on the environment?"

According to the Intergovernmental Panel on Climate Change (IPCC), a leading international body established by the United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO), air transport contributes to 4.9 per cent of human-caused climate change, including emissions of carbon dioxide and other greenhouse gases.

In a year, nine billion passengers are flown around the globe and the number is expected to only go up. In the Middle East, research by Airbus has revealed that air traffic in the Middle East will double in the next 10 years, and by 2034, the passenger fleet of airlines in this region will grow by 2365 new passenger aircraft. As the demand for air travel increases, there is now a greater need to examine ways to reduce its potential damaging effects on our planet.A major contributor to global warming is kerosene, a fuel used to power aircraft engines, which is not only a scarce resource but also emits carbon dioxide.

the main aim of conducting the present study is to identify the environmental issues faced due to the airline industry. It can be expressed as the issues like global warming, climatic change, noise pollution, toxic emissions, etc. Improving the environmental performance of aviation is a challenge we need to take very seriously. In fulfilling these responsibilities, I have developed a range of standards, policies and guidance material for the application of integrated measure to address aircraft noise and emissions embracing technological, improvements, operating procedures, proper organization of air traffic, appropriate airport and land-use planning, and the use of market-based options.

1.4 Research Hypothesis

There were several Research Hypothesis that were drawn from this study.

Hypothesis. 1: "Public are not aware of the legal aspects of environment".
Hypothesis. 2: "Aviation industry is more profit based rather than being mindful of their activities and how they will affect the future".
Hypothesis. 3: "NGOs are not publicizing or enhancing their environmental awareness programmes to the masses"
Hypothesis. 4: "There is currently no mode of transport in the world that is as fast and as time efficient as the Aviation Industry.

Chapter 2

2.0 Literature Review

Comprehensive research shows that despite anticipated efficiency innovations to airframes, engines, aerodynamics and flight operations, there is no end in sight, even many decades out, to rapid growth in CO2 emissions from air travel and air freight, due to projected continual growth in air travel. This is because international aviation emissions have escaped international regulation up to the ICAO triennial conference in October 2016 agreed on the CORSIA offset scheme. In addition, due to low or non-existent taxes on aviation fuel, air travel enjoys a competitive advantage over other transportation modes due to lower fares. Unless market constraints are put in place, growth in aviation emissions will result in the sector's emissions amounting to all or nearly all of the annual global CO2 emissions budget by mid-century, if climate change is to be held to a temperature increase of 2 °C or less. In this section we briefly review the relationship between aviation and the environment, including what is known about community noise impacts, air quality impacts and climate impacts, the interdependencies between these effects and opportunities to address them, constraints on mobility, economy and national security and interactions between governmental and other organizational structures to address these impacts.

Taken together, these studies present a compelling case for urgent national action to address the environmental effects of air transportation. Aviation is a critical part of our national economy, providing for the movement of people and goods throughout the world, enabling our economic growth. Despite dramatic progress in reducing the environmental effects of aviation, and despite the relatively small contribution that aviation currently makes to environmental impacts in the United States, environmental concerns are strong and growing. As a result of growth in air transportation, emissions of many pollutants from aviation activity are increasing against a background of reductions from many other sources. In addition, progress on noise reduction has slowed. Although it depends on the metric used, estimates suggest that millions of people are adversely affected by these side effects of aviation. Because of these factors and the rising value placed on environmental quality, there are increasing constraints on the mobility, economic vitality and security of the nation. Airport expansion plans have been delayed and cancelled due to local air quality, water quality and community noise impacts. Military readiness is increasingly challengedby restrictions on operations. These effects are anticipated to grow as the economy and demand for air transportation grow. Indeed, as highlighted by the National Science and Technology Council, and later by the National Research Council, if they are not addressed, environmental constraints may impose the fundamental limit on the growth of our air transportation system in the 21st century. India is not the only force in this arena: non-Indian concerns and regulatory actions are increasingly setting conditions for the world's airlines and manufacturers. For example, within the European Union the climate effects of aviation are identified as the most significant adverse impact of aviation, exceeding the importance of local air quality and noise impacts that are the current focus of attention in India and many other nations. As a result, there are increasing calls for regulation: trading, taxes and charges, demand management and reduced reliance on aviation. However, there is considerable uncertainty in assessing the climate effects of aircraft and determining appropriate means to mitigate these effects. Despite the importance of this issue, the India does not have a significant research program to assess the potential impacts of aviation on climate. This must be remedied to enable strong U.S. participation in international forums and continued competitiveness in world markets. The international concerns will continue to grow with the strong increase in air transportation demand anticipated for Asia. Within India there are hundreds of organizations and groups (federal, state, local, aerospace industry and community groups) whose principal focus is aviation noise and emissions. The participants are dedicated to their charge and when focused can be very effective in bringing about change. However, in general, the activities of these organizations are not well coordinated and acting singly they are not likely to alter our national path in a substantive manner. To become more effective these organizations must better coordinate their activities to address the growing challenge of aviation and the environment. This change, the development of a new paradigm for organizational interaction and coordination at the national level, emerged from the study as one of the most important opportunities for improvement. Both requirements and incentives for coordinated action should be considered. With greater coordination, many opportunities for long-term environmental improvements can be realized. A critical requirement to capitalize on these opportunities is the development of better metrics and tools for assessing interdependent impacts, and options for addressing them. The tools currently used to estimate the costs and benefits of proposed improvements do not effectively address either the strong interdependencies between actions or the full economic consequences of different choices. Once they are developed, these tools should be used to assess the many opportunities for long-term environmental improvements that exist in the domains of technology, operations, and policy. Most ofthese opportunities are being pursued in some form, but most are not sufficiently funded to promote rapid change. We discuss in the following sections the specific connections between aviation and the environment. We focus on community noise, local air quality and climate change. We do not review the literature on water quality. However, this is also an important environmental impact; water quality issues are limiting several airport expansions projects. Water quality issues must also be addressed in the future

2.0.1Growth of Aviation.

Aviation has the highest growth rates of all modes of transport. Annual global growth rates of aviation (total number of kilometres flown by all passengers) were approximately 10% in the 1960s and had values of 5% -7% in the 1990s. Between 1960 and 1995 global tonne-kilometres (total weight of freight carried multiplied by the distance flown) increased by a factor of 23, while the global gross domestic product increased by a factor of 3.8.

Global revenue passenger kilometres (RPK) rose by a factor of 4.6 between 1970 and 1995. Air traffic in and from/to North America and Europe dominates the world demand. In 1995 intra North American aviation accounted for 27.5% of global RPK, intra Europe 12.5%, North America - Europe 11%, Asia to North America and Europe 12.7%, and all the rest 36.5% of global RPK. However, the highest growth rates are found today in Asia (intra-Asian RPK rose by 20% p.a. between 1970 and 1995). These data are the main input for all demand forecasts.
The India air traffic forecasts (AAI) predict that there will be 360 million passengers going through Indian airports in 2020, up from 129.6 million in 1995. This is a change of 259% and an actual increase of 220.4 million passengers, the equivalent of an extra 3-4 airports the size of Delhi Airport.

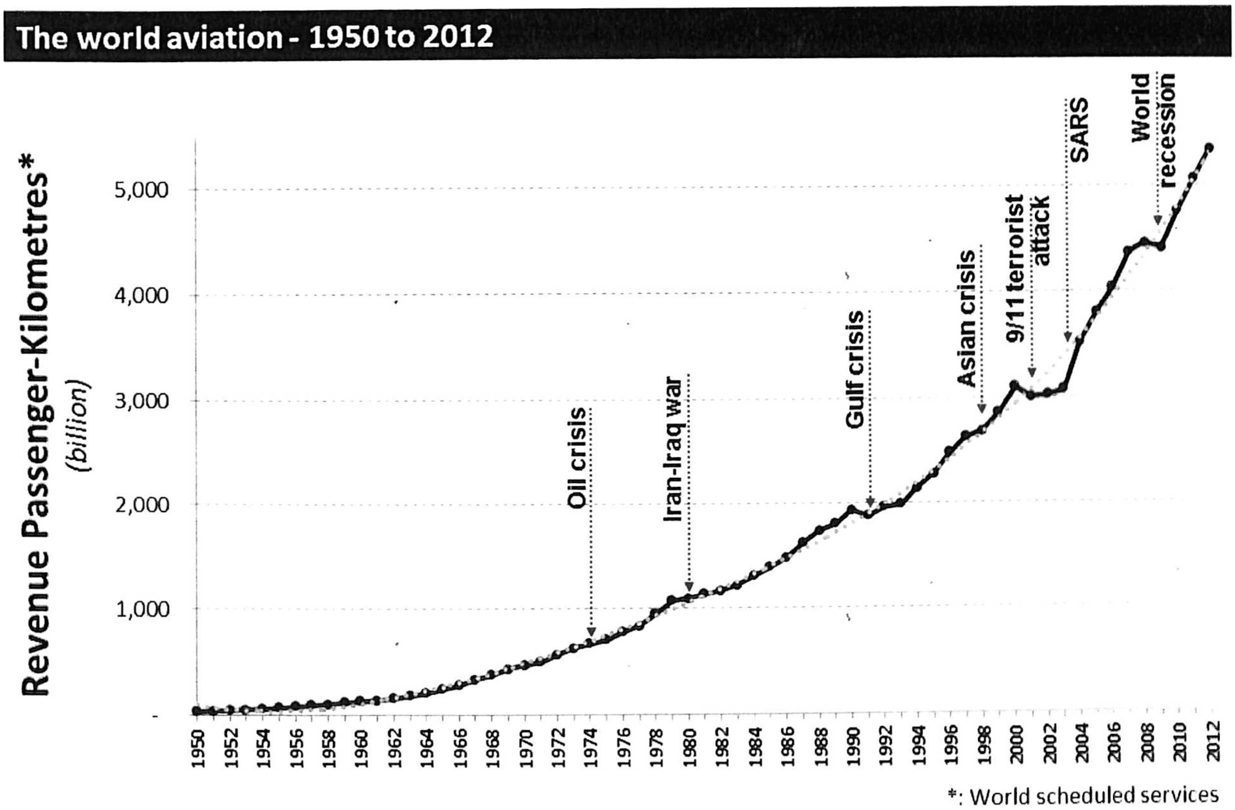

Table 1: Revenue Passenger-Kilometres

2.0.2 Noise.

Noise is not just annoyance. It damages health, it detracts significantly from the quality of life, it stops local residents enjoying their gardens or simply enjoying peace and quiet, it damages wildlife, it damages the learning ability of schoolchildren and it costs a great deal of money through the costs of noise mitigation and noise abatement. Aircraft noise is a serious concern around all airports and under flight paths notwithstanding the adoption of quieter aircraft and engine technology. Aircraft noise is a controversial matter. It is frequently asserted by the aviation industry that the number of people exposed to noise problems, the so-called noise footprint, is shrinking rapidly. This is disputed by residents and has been shown at the Heathrow Terminal 5 inquiry to be based on unreliable and outdated data (HACAN News, December 1997). Almost every aspect of aircraft noise is the subject of disagreement. The selection of a measure of noise can influence the extent to which noise is recognised as a problem. Measures that average values over long time periods can show low relatively levels of noise and measures that emphasise peak events can show serious noise problems. More discussion on measurement problems and selection can be found in the technical appendix together with an illustration of typical noise levels from different activities and the levels above which most people experience communication difficulties, sleep disturbance or discomfort.

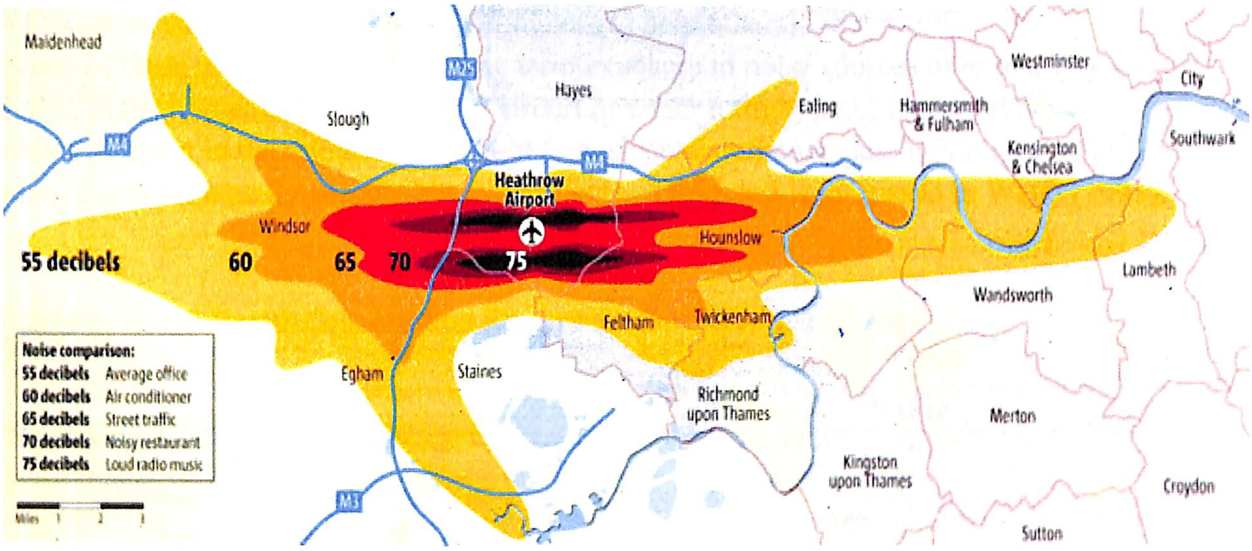

Illustration 1: Noise Pollution Recorded at London Heathrow International Airport (LHR)

As shown in the Image above, Noise is measured on the Decibel "A" Scale usually expressed as dB(A). The scale is used by public health and environmental health officials to set limits or make recommendations about limits that should not be exceeded. A limit of 55dB(A) is regarded as one which should not be exceeded to protect undisturbed sleep and sound levels above 70dB(A) make normal speech communication impossible (European Environment Agency, 1995).

Effects of noise on humans

The World Health Organisation 1993 document, "Community Noise" (WHO, 1993) reviews the international scientific evidence on the effects of noise. These include:

- Hearing impairment
- Pain
- Perceived noisiness and annoyance
- Interference with communication and speech perception
- Sleep disturbance

• Psychophysiological reactions during sleep (including effects on heart rate, finger pulse, respiration)
• Stress
• Cardiovascular effects
• Psych endocrine effects
• Startle reflex and orienting response
• Effects on physical health (including nausea, headache, irritability, instability, argumentativeness, reduction in sexual drive, anxiety, nervousness, insomnia, abnormal somnolence and loss of appetite)
• Mental disorders
• Task performance and productivity
• Deficits in reading acquisition among children
• Effects on social behaviour (e.g. willingness to help others)

Some of these effects will require long term exposure to noise sources over many years (e.g. living in the immediate vicinity of an airport or under a flight path) whilst others will require only one event in the middle of the night (e.g. sleep disturbance) and it is highly unlikely that all subjects are equally susceptible to all effects. The detail is discussed in WHO (1993).

Table 2: World Health Organisation Recommended Noise Thresholds.

Context	**Value**
Bedroom	30
Balconies, Terraces, Gardens	55
Outdoors at Night-time	45
Schools and Colleges	35
Outdoor Playgrounds	55
Inside Hospitals	35
Single Noise Event in Dwelling	45

Source: WHO 1993

These values are thresholds that should not be exceeded. They present planners and regulatory regimes with considerable problems. More importantly they present local residents with problems. Everyone living in the vicinity of an airport or under a flight path is potentially living in a noise regime that exceeds these thresholds. Primary schools, secondary schools, hospitals and homes for the elderly are also exposed to noise levels that exceed these WHO threshold values. The growth of aviation will make the problem worse and currently there is no governmental or industry response that can guarantee noise reductions to safe WHO levels.

2.0.3 Ground Level Air Emissions.

The structure of atmosphere can be categorized into five main layers; i.e. Troposphere; Stratosphere; Mesosphere; Thermosphere; Exosphere and Ionosphere. The aircraft pollution may be categorized into atmospheric layers (Co^2; NOx and Ozone) and ground pollution.

Firstly, focusing on the pollution at atmospheric layers level; modern day passenger aircrafts travel at 35000ft. and the aircraft engines emit exhaust. Unlike many other sources, however aircraft emit pollutants over a range of altitudes, but their emissions differ at differentaltitudes. The exhaust chiefly comprises of CO_2 (Carbon dioxide), the major greenhouse gas. CO_2 gas is heavier than air and its relative density to that of air is 1.53, freezing point is 56^0C. The altitude at which the commercial airlines fly, the outside temperature varies between -35^0 C to -50^0C and this is slightly warmer than the freezing point of CO_2. The CO_2 released from the engine exhaust will not condense; instead it will begin dispersing slowly because the vapor pressure of the CO_2 gas at that temperature is 101. It will descend to lower altitudes. These are factors that add to the slow descending nature of these gases and it is mainly due to the fact that these gases are released at much higher altitudes from where the precipitation of water and snow to the ground level takes place and also, there is no vegetation/sink to absorb these gases. It can be also mentioned that the blanket of this greenhouse gas is more effective at the stratospheric levels than lower altitudes at blocking the escaping radiant energy from the earth. It can be stated that the emissions from the aircraft below the mixingheight contribute to the ground level air pollution, while there can be a severe impact on the climate change when the emissions are above the mixing height. Aircrafts are classified as air carriers, air taxi operators, general aviation and military aircraft. This classification is in accordance with the landing and takeoff cycle.

The NOx constitutes the next most abundant gas after CO_2 (the emission indices range from 5 to 25g of NO_2 per kg of fuel burned), the aircrafts carbon mono oxide CO emissions are of the same order of magnitude of NOx emissions (i.e. 1-2g/kg for Concorde aircraft and 1-10g/kg for a subsonic aircraft). It is very important to look more into the reality that the concerns related to the emissions of NO and NO2 from modern jetliners ranging from subsonic to supersonic aircrafts were known more than 20 years agoby Hidalgo and Crutzen because these emissions could damage the ozone layer. Volatile organic compounds play a significant role in hampering the functionality of the ozone that is present in the aircraft's emissions. The interrelations of these compounds have also been seen in the condensation trails and cloud formation. As the aircrafts fly at altitudes between 9-13 km above the Earth's surface, so at that altitude (25000ft-35000ft) the chemistry of the gases from the engines lead to a special characteristic phenomenon called as condensation trails or contrails. Now the very interesting feature of these contrails is that their formation is relatedto the cloud formation.Taking note of the Ozone and Ozone-hole Phenomenon; the formation of ozone occurs when the ultraviolet radiations from the sun strikes the stratosphere striking or disassociating the oxygen molecules (O_2) into atomic oxygen (O) this atomic oxygen then combines quickly with O_2 molecules that ultimately yields ozone (O_3) and this process continues and is termed as "ozone-oxygen cycle. Direct aircraft emissions include pollutants like CO_2 and H_2O that can affect climate. But there are certainly other effects like production of ozone in the troposphere, alteration of methane lifetime, contrail and cirrus cloud formation. The emissions which can hamper stratospheric ozone (i.e. nitrogen oxide, water vapour) do so indirectly by manipulating the chemical balance in the stratosphere. Subsonic aircraft fly in the troposphere and lower troposphere while supersonic aircrafts fly in the stratosphere 80-85% of the times, which cruise altitudes many kilometres above the subsonic aircraft. Hence, it is more crucial to analyse the physical and chemical processes of the two regions. Emissions from aircraft as water vapours by a large pool of aircrafts into the troposphere are less when compared to the fluxes in the natural hydrological cycle. But still their role in cirrus cloud formation and contrail formation cannot be neglected. The special property of the aircraft is that they cruise at varying heights. Now the effects of these aeroplane emissions depend strongly on the flight levels (altitudes) and whether they fly in troposphere or stratosphere, 7-25% of the total ozone mass is transported to the extra tropical troposphere and this type of movement cycle occurs mostly in winter in the northern hemisphere.

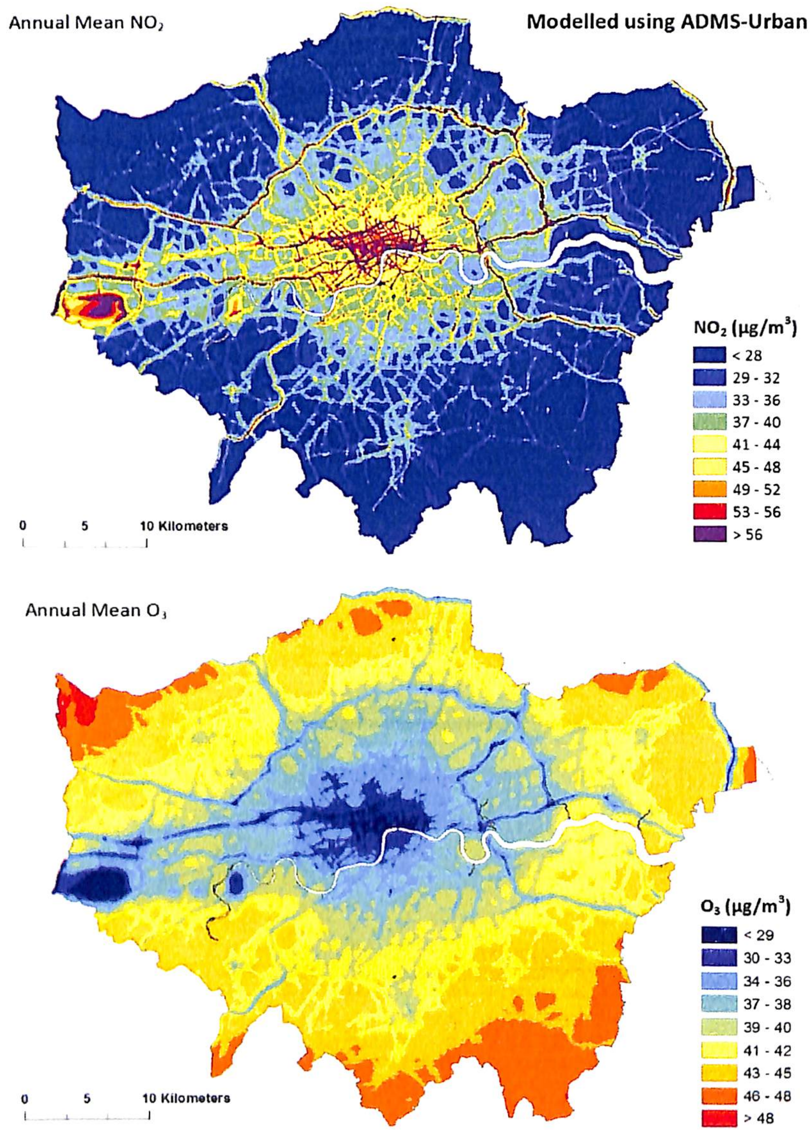

Illustration 2: A Comprehensive Annual Map Recording the Nitrogen Oxide Gas and Ozone Gas in the City of London.

Secondly, focusing the pollution on ground, the author looks in terms of chemicals, which are sprayed on the aircraft exteriors to remove the ice. These compounds are known as de-icing fluids. De-icing is the process of removing the frozen contaminants, snow, ice and slush from the surface. Anti-icing is the process of protecting against the formation of ice, snow on the surface of the aircraft. De-icing fluids have been designed to reduce the freezing point of water and these fluids are always applied heated and diluted. During the freezing and precipitation conditions it becomes very essential to carry out the de-icing procedure because even a little ice/snow cover can hamper the aerodynamic lift of the aircraft and can be disastrous.

The other main aspect to de-ice the aircraft is to keep the various sensors, Pitot tubes free from ice. These sensors and antennas are present on the belly, roof, near the forward nose and on the wings of the aircraft. A Boeing 737 aircraft has not less than 200 sensors and, as they are crucial for accurate onboard flight computer systems. The de-icingfluids widely incorporated for this purpose are "propylene glycol" (PG) or "ethylene glycol" (EG). EG is still in some countries because of its lower operational use temperature (LOUT) than propylene glycol, which is classified as non-toxic. The formulation of these de-icing fluids falls into two major categories: heated glycol diluted with water meant for frozen snow/frost removal, also known as "Newtonian fluids" and unheated undiluted glycol that has been thickened like a half set gelatine. These are also referred as "non-Newtonian fluids" that are applied to curb the future development of falling ice from accumulating. In some cases, both types of fluids are applied-first the heated glycol followed by unheated, thickened coating of glycol. This is known as a "two-step procedure". The Propylene Glycol Industrial Grade (PGI) is the preferred choice for de-icing fluid for aircraft de-icing formulations due to its low freezing point; low toxicity; biodegradability; ease of handling; low corrosive nature of metals and low flammability.

Illustration 3: De-icing of an Aircraft.

De-icing is the process of removing snow, ice or frost from a surface. Anti-icing is understood to be the application of chemicals that not only de-ice but also remain on a surface and continue to delay the reformation of ice for a certain period of time or prevent adhesion of ice to make mechanical removal easier.

De-icing can be accomplished by mechanical methods (scraping, pushing); through the application of heat; by use of dry or liquid chemicals designed to lower the freezing point of water (various salts or brines, alcohols, glycols); or by a combination of these different techniques.

2.0.4 Airports-Environmental Issues.

Airports have also been accused of degrading the environment due to various factors. Even the slightest variations in terms of going against the environmental norms could lead to suspension of operations, which we do not expect and are striving towards a friendly approach. A major role for pollution caused at airports is by ground access vehicles (GAV) and ground support equipment (GSE). All these vehicles include; the staff jeeps; cars; heavy duty pushback trucks; ground power units; passenger terminal buses; catering trucks; cleaning trucks; mobile air-conditioning units.

Apart from the above, aircrafts also contribute to the pollution crisis at the airports especially during peak hours in the morning and evening, as the aircrafts line-up waiting for take-off clearance while others have their engines idling and one clearly make out the foggy, hazy and smoky environment at the airports tarmacs and thresholds of the runways. Even when present on ground, the emissions from different categories of aircrafts and airport vehicle's emissions include harmful $NO_{x,}$ CO2 compounds that have very serious consequences on health of people residing nearby and to those lying directly below the flight path (during take-off and landing). These compounds are carcinogenic in nature.

Another defying aspect of airport pollution is the biodiversity that includes plants/tree plantations and avian (birds) and has become at the brim of destruction while an airport is freshly under construction. The construction of airport involves clearing of planted lands that are usually speak over vast areas and hectares (as 5500 Acres) of fields of plantations like rubber or filling up of marsh areas with tremendous amount of sand and concrete like in case of Singapore's Changi airport or Bangkok's Suvarnabhumi Airport. This type of destruction creates a huge imbalance in the ecosystem and may lead to disturbances in the ecological good chain. But even after the completion of the airport project, they continue to pose threat to biodiversity like bird strikes or bird hits and safe recycle techniques of airport waste and water.

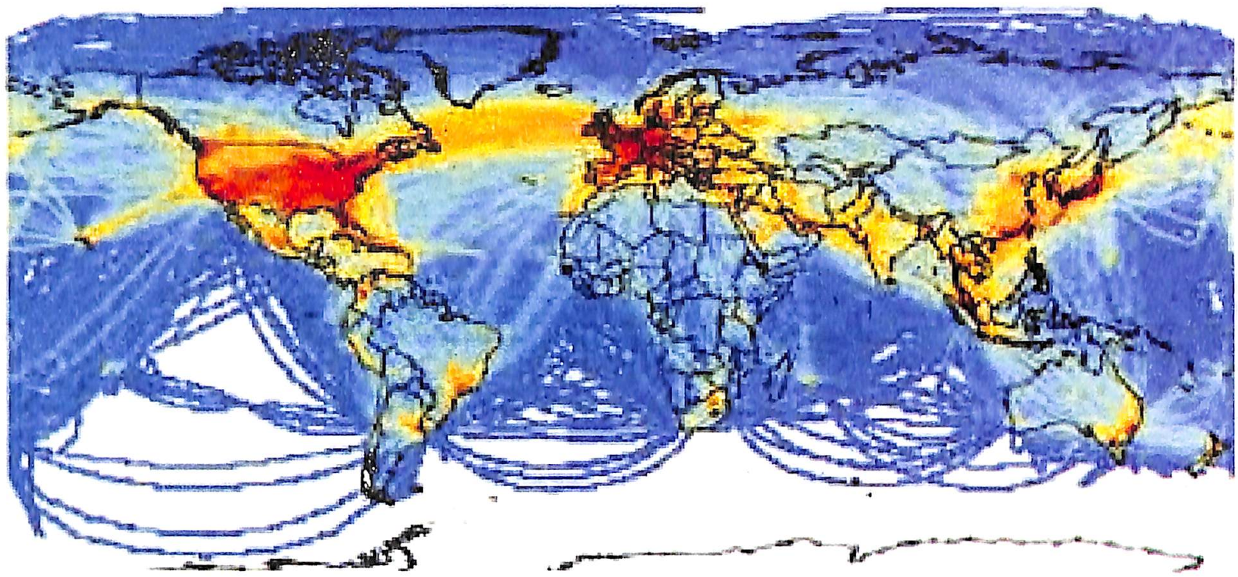

Illustration 4: ThisoutputfromtheFAASystemforassessingAviation'sGlobalEmissions(SAGE)showstheworld-widedistributionofaircraftcarbondioxideemissionsfor2000.

2.0.5 Local Air Quality

Although noise is the primary environmental constraint on airport operations and expansion, many airports either put local air quality concerns on equal footing with noise or anticipate they will be on equal footing soon . Emissions of nitrogen oxides (NOx), carbon monoxide (CO), unburned hydrocarbons (UHC) and particulate matter (PM) from a variety of airport sources contribute to local air·quality deterioration, resulting in human health and welfare impacts. Nationally, local air quality has steadily improved as a result of the Air (Prevention and Control of Pollution) Act, 1981, which has led to reductions in pollution from most sources . However, many of the technologies employed for land-based sources are not applicable to aircraft because of the more severe weight, volume and safety constraints. Thus, although aviation is a small overall contributor to local air quality impacts, some aircraft emissions are growing against a background of generally decreasing emissions from other sources. Historically, the most difficult of the pollutants to control for aviation has been NOx. Aviation operations below 3000 feet contribute 0.4% to the total national NOx inventory. Forty-one of the 50 largest airports are in ozone non-attainment or maintenance areas. In serious and extreme status non-attainment areas, the airport contribution to the area NOx inventory ranges from 0.7% to 6.1% with an average of less than 2% . The contribution of aviation to NOx emissions around airports is expected to grow . There are physical and chemical phenomena that make it more challenging to reduce NOx emissions from aircraft engines that employ high temperatures and pressures to reduce fuel consumption. However, there are alternatives for reducing NOx that do not require trade-offs with fuel efficiency; improvements in combustor technology and airframe aerodynamics and weight have led to reductions in NOx emissions without negative effects on fuel efficiency. Over the last 35 years fuel burn per passenger-mile has been reduced by 60%. Two-thirds of this reduction has been due to improvement in engine technology with the rest due to improvements in aerodynamics, weight and operations. Continuation of ongoing technology research is expected to reduce fuel consumption at a slower rate—about 1% per year over the next 15 to

20 years—with more opportunities for improvement in airframes than engines. However, the demand for air transportation is expected to increase 3% to 5% per year. Low emissions technology and operations must therefore make up the difference to avoid increased pollutant emissions from aircraft. There are many opportunities for technological and operational improvements to reduce emissions of NOx, UHC, CO and PM. These options for reducing emissions present major engineering, safety and cost challenges that must be overcome before they can be implemented in the fleet. Research programs in the United States and Europe have been developed to address these challenges. By 2020, the European community hopes to make an 80% reduction in NOx emissions. In 2007, NASA planned to develop technology to reduce NOx emissions of new aircraft by 70% from 1996 International Civil Aviation Organization (ICAO) standards with additional plans to further reduce NOx by one-third of the remainder. These reductions will focus on engine developments. NASA has already demonstrated TRL 4 technology for a 67% reduction in NOx emissions below 1996 standards. However, the National Research Council determined that NASA funding is insufficient to reach the specified milestones for reducing NOx emissions on schedule . There are also several promising operational opportunities for reducing fuel burn and emissions such as single-engine taxi, modified take-off and landing procedures, and modernization of the air traffic management system to reduce Enrooted and ground delays. Less attention has been given to these in national research plans, but increased focus is warranted because they may enable relatively near-term reductions. Two areas of increasing importance and high uncertainty relating to local air quality have emerged for aviation in the last decade. The first is fine particulate matter (PM). On a perpound basis, the mortality and morbidity costs of PM are several hundred times greater than those resulting from emissions of NOx. While the Centre has introduced increasingly stringent national ambient air quality standards for particulate matter, there are currently no uniformly accepted methods for measuring both the PM and PM precursors from aviation. The aviation community is thus challenged first to measure and characterize the pollutants, then to assess the impact of the pollutants, and finally to adopt strategies to reduce them if warranted. Airports are required to address conformity and other requirements as part of expansion or improvement projects, so mitigating actions may be required, even though there is little understanding of aviation PM, its health impacts, and the relationship with aviation technology and operations. DGCA, ISRO, The Centre, industry and academic institutions have joined to develop a National Roadmap for Aviation Particulate Matter Research to outline the efforts required in this area. The second emerging local air quality concern is the potential for aviation to contribute hazardous air pollutants (HAPS) to local environments. In recent airport environmental assessments, HAPS reviews have figured more prominently . In these recent cases HAPS associated with emissions from the airport were not found to produce significant health impacts. However, the estimates of HAPS emissions used in these reviews were developed using measurements from 35-year-old engine technology because no other data were available. Here again, the aviation community is challenged to first measure and characterize the emissions and then to adopt strategies to address them if warranted . Current plans are not enough to meet this need. As a result, more airports may find themselves in the difficult position of being required to pursue mitigation measures without the benefit of the proper tools to measure and characterize the pollutants and assess the potential impacts.

2.0.6 Climate Change

The topic of greatest uncertainty and contention is the climate change impact of aircraft. In Europe, this is considered the single most important environmental impact from aviation, while in the United States many still regard it as less important and less urgent thancommunity noise and local air quality. It is a fact that aircraft emit chemical species and produce physical effects (like condensation trails, or contrails) that most scientists believe affect climate. Scientific assessments also suggest that the resulting chemical and physical effects due to aviation are such that aviation may have a disproportionate effect on climate per unit of fuel burned when compared to terrestrial sources.

In 1999, a special aviation study, conducted by the Intergovernmental Panel on Climate Change (IPCC) estimated that aviation was responsible for approximately 3.5% of the anthropogenic forcing of the climate in 1992. These estimates reflect a finding that per unit of fuel burned, radiative forcing from aircraft is expected to be approximately double that of land-based use of hydrocarbon fuels. Since the IPCC study, the scientific understanding of some of the chemical and physical effects (particularly contrails and the cirrus clouds they may induce) has evolved. A recent report by the UK Royal Commission on Environmental Protection (RCEP) stated that the net effect of contrail and aviation-induced cirrus is expected to be three to four times the radiative forcing due to the CO2emitted from aircraft, although further changes in these estimates are likely. If the estimates are correct and the aviation growth projections used by the IPCC are realized, aviation may be responsible for between 3% and 15% of anthropogenic forcing of climate change by 2050.

Because of the uncertainty in understanding the impacts of aviation on climate, appropriate technological, operational and policy options for mitigation are also uncertain. As a result, most mitigation options currently being pursued focus on reducing fuel burn. However, as noted in Section 3.4, it is possible that this is not the most effective strategy for reducing aviation's contribution to climate change. Further, although fuel use per passenger-mile has been reduced by 60% in the last 35 years, most projections suggest a slower rate of improvement in the next 15 to 20 years—about 1% per year—falling short of the expected growth in demand. NASA has a five-year goal to deliver technologies needed to reduce CO2 emissions of new aircraft by 25%. However, significant challenges will remain todemonstrate technological feasibility and economic reasonableness such that these concepts can be employed in the fleet. As a result, it may take an additional 5 to 15 years and significant industrial investment before these NASA technologies can be introduced into new aircraft. Within Europe, public and governmental positions increasingly point towards a desire to regulate the climate impacts of aircraft. The RCEP noted that without regulatory control, the rapid growth of air transport will proceed in fundamental contradiction to the British government's stated goal of sustainable development. Britain would argue strongly for aviation to be brought within the next phase of an EU emissions trading scheme. It would set a cap on emissions and require companies increasing output to 'buy' unused capacity from elsewhere. While the United States has increased investment to reduce uncertainty in climate change impacts generally, there are currently no major research programs in the United States to evaluate the unique climate impacts of aviation. This may put the United States at a disadvantage in evaluating technology and policy options, and in negotiating appropriate regulations and standards with other nations. It could also lead to reliance on data put forth by others who may favour curtailing aviation activity to mitigate environmental impacts, despite its significant contribution to the economy.

2.0.7 Interdependencies

Noise, local air quality and climate effects of aviation result from an interdependent set of technologies and operations, so that action to address impacts in one domain can have negative impacts in other domains. For example, both operational and technological measures to reduce noise can result in greater fuel burn, thus increasing aviation's impact on climate change and local air quality. Emissions interrelationships make it difficult to modify engine design as a mitigation strategy since they force a trade-off among individual pollutants as well as between emissions and noise. To date, interdependencies between various policy, technological and operational options and the full economic consequences of these options have not been appropriately assessed. The EPA has recommended that government and industry invest in comprehensive interdisciplinary studies that quantify the marginal costs of environmental protection policies . Such investments are now being made. Over the next six years the DGCA and ISRO plan to invest $10M per year to develop a comprehensive framework of aviation environmental analytical tools and methodologies to assess interdependencies between noise, emissions, and economic performance to more effectively analyse the full costs and benefits of proposed actions. These tools will be critical for informing decisions on new noise and emissions standards, potential phase-outs of portions of the fleet and potential cruise emissions standards. They are also required to define appropriate research and development investments for technological and operational opportunities for reducing noise and emissions. These tools can offer significant leverage because of the billions of dollars invested in developing and operating aircraft. The development of such tools will be a major step forward for the nation.

2.0.8 Mobility, Economy and National Security

Aviation enables economic growth. The Presidential Commission on the Future of Aerospace found that the superior mobility afforded the United States by air transportation is a major national asset and a competitive advantage, but United States dominance in aerospace is eroding. The Air Transport Association estimated that the total direct, indirect and induced impact of commercial aviation exceeded $800B and 10 million jobs in 2000, representing 8% of India' gross domestic product. From 1998 through 2011, the number of passengers boardinggrew from slightly over 300 million to over 600 million annually. Indian businesses also shipped more by air: from 1998 to 2011, air freight ton miles grew from 6 million to over 20 million annually. From 1998 through 2013, revenue passenger-kilometres flown by large certificated air carriers increased by a factor of 2.8 to approximately one trillion passenger kilometres per year. At the same time airline ticket prices have fallen approximately 50% in real terms (adjusted for inflation) since 1998 . Large carrier traffic in India and international passenger traffic are both expected to continue to grow,with international markets growing faster than domestic markets (4.7% versus 3.5% annually) over the next 12 years. At the same time, restructuring of large legacy carriers and the growth of low-cost carriers is anticipated — low-cost carriers and regional and commuter carriers could account for more than half of all domestic passengers by 2015. Forecasts for air cargo and general aviation indicate growth as well . The India national air transportation system is not enough to accommodate this growth. Five of the top 15 Indian airports neededadditional capacity in 2013; 9 of the top 20 airports are projected to need additional capacity by 2023. If improvements proposed in the DGCA Operational Evolution Plan (OEP) do not take place, the number of airports requiring additional capacity in 2013 increases to 26 of the top 35 airports. Further, even with these capacity expansions, new airports may have to be built to satisfy demand projections in many metropolitan areas. Environmental issues caused airport officials to cancel or indefinitely postpone expansion projects at 12 of the 50 busiest Indian airports in the last 10 years. The dominant concern was noise, followed by water quality and then local air quality. In the future, noise and local air quality are expected to be the most significant concerns.

Although the situation is different for military aviation, similar challenges exist. Increasing impacts on national security have been recognized due to constraints on the deployment and combat readiness of the airborne services, particularly as related to limitations on the realism of training activities . While commercial aviation has grown, military aviation has experienced reductions in fleet size and number of operations over the last 10 years. However, technological and operational improvements in noise and emissions for military aircraft have been more challenging to achieve because of the mission requirements for these vehicles. Nonetheless, because of the decreasing number of operations, military aviation has been responsible for a small and decreasing fraction of total fossil fuel use in India. Further, when averaged nationally, contributions to local air quality impacts and community noise have also decreased from 1990 to 2000. However, since base closures were largely responsible for these reductions, the impacts at any given installation may not reflect overall trends. Thus, community noise and air quality are expected to be a growing concern for military aviation due to increasing urbanization and increasing public and regulatory attention.

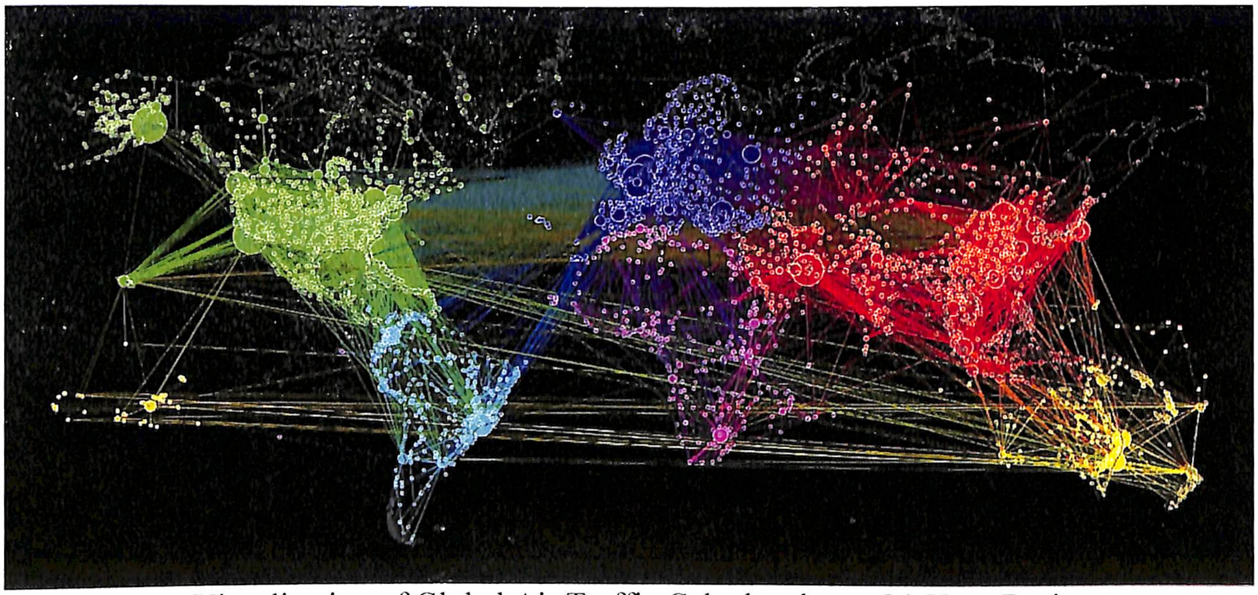

Illustration 5: Visualization of Global Air Traffic Calculated on a 24-Hour Basis.

2.0.9 Interactions between Government, Industry and Other Groups

A distinct difference exists between the approaches of Europe and India to address the challenges described above. Europe has plans and programs focused on making it the global aeronautics leader by jointly satisfying aviation safety, environment and mobility demands by 2030 . The Advisory Council for Aeronautics Research in Europe (ACARE) was formed to coordinate the positions of international institutions that support the aerospace industry and to launch and approve a Strategic Research Agenda and update it every two years. AERONET was established as a platform for aviation emissions issues in Europe where the different stakeholders can meet, communicate and cooperate in a well-organized and systematic way. As Europe has moved to act in a coordinated fashion, several studies and reports have encouraged independent European action on charges and economic instruments to address noise, air quality and climate change, outside of the ICAO framework . Taxes, demand management and modal shift have been recommended to curb growth and impacts. The foundation for these recommendations is the belief that current levels of air traffic cause major environmental costs that will grow unless economic instruments are instituted to curb them . These recommendations reflect the very different context within Europe relative to infrastructure (greater availability of rail) and governmental policies to address environmental costs. Less coordinated action is apparent within India, but there have been several recent activities. The General Accounting Office (GAO) has called for the creation of a national strategic framework for local air quality emissions. The Presidential Commission on the Future of Aerospace found that India government functions in a vertical manner in different organizations, whereas national problems cut across organizations and need horizontal integration. There are also growing cross-agency research programs. For example, FAA, NASA, and Transport Canada have jointly sponsored a Centre of Excellence called Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) to address issues of aviation and the environment by utilizing the resources available in academia and industry . These activities are moving the nation in the right direction, but at a pace that far lags the burgeoning need. When we asked the stakeholders to describe prior successes and failures, communication and coordination between organizations was the key enabling or disabling factor in all the examples they offered. Examples were given of poor coordination among NASA, FAA, EPA and the National Park Service and of poor coordination between groups within agencies. Conversely, past successes all bridged boundaries between various groups and organizations. Perhaps the most prominent example is the Aircraft Noise and Capacity Act of 1990 described earlier. This was a negotiated legislative response involving all stakeholders that led to the incorporation of NASA and industry technology into the fleet faster than it otherwise would have been, producing substantial reductions in community noise along with reductions in per mile fuel burn and per mile emissions. A key compromise involved enacting federal guidelines for communities in setting local aircraft noise limits and restrictions, while requiring airlines, at a cost of $5B or more, to phase-out noisier (Stage 2) aircraft under a proscribed timetable. Another example was the Federal Interagency Committee on Noise (FICON) that produced a report in the early 1990s covering policy, technical and legal issues. The study endorsed supplemental metrics and reinforced methods for DNL levels. It led to more clarity on how to assess certain noise impacts, and it reduced tensions between stakeholders. The NASA Atmospheric Effects of Aviation Program (AEAP) was a successful exampleof the NASA Science Directorate working with the NASA Aeronautics Directorate on basic research focused on a specific problem with participation from EPA, FAA, academia and industry. Although widely regarded as successful, lack of sustained long-term funding led to cancellation of the program, and the research community that was developed around the program dissipated. At the community level, provisions in the Vision 100–Century of Aviation Reauthorization Act (P.L. 108-176, and CFR part 150, Airport Noise Compatibility Planning) are effective in the way they tie funding to better communication between communities and airports. There are also isolated examples of effective forums for engaging the community. The O'Hare Noise Compatibility Commission and the San Francisco International Airport/ Community Roundtable each include multiple stakeholders working together in ongoing forums with local political leadership and airport management support. The relationships that have emerged among industry, towns, cities, counties, schools, airports, and airlines have made these forums successful. They are recognized nationally as effective examples of intergovernmental cooperation regarding aviation noise impacts and mitigation efforts in affected communities. Stakeholders feel they are part of a process that encourages continuing growth in the quality of life of local residents and the economy. In summary, a key finding of this study is that promoting greater coordination and communication among stakeholders presents a major opportunity for improving the nation's ability to jointly address mobility and environmental needs.

2.1 Summary

To Summarize, the airlines must rely on airport infrastructure and air navigation services that the industry neither owns nor controls. Supply in the form of infrastructure capacity has not kept pace with aviation's growth. The resultant capacity limitations have led to increased congestion, both on the ground and in the skies. This causes delays, system inefficiencies and unreliability and produces considerable additional energy consumption and emissions. Were governments to establish the necessary institutional framework, improvements in air traffic management and other operational procedures could have reduced the fuel burn by 8-18% system-wide? For the current worldwide fleet, improvements to the ATM system alone could reduce fuel burn per trip by 6-12%.

While aircraft environmental performance has been important since the beginning of commercial aviation, continuously increasing commercial traffic and a rise in public awareness have made aircraft noise and emissions two of the most pressing issues hampering commercial aviation growth today. Except the Aviation Environmental Unit (AEU) an initiative of the DGCA, no real framework exists to address the environmental impact of aviation in India. The AEU in its limited capacity has proposed measures to control noise; create emission inventory and encourage fixed power usage at airports. Hence, the body needs to be strengthened to implement the aforesaid measures. A regulatory authority be constituted to curb the future environmental issues pertaining to aviation industry in India.

Chapter 3

3.0 Research Design, Methodology and Plan

As it is indicated in the title, this chapter includes the research methodology of the dissertation. In more details, in this part the I outline the research strategy, the research method, the research approach, the methods of data collection, the selection of the sample, the research process, the type of data analysis, the ethical considerations and the research limitations of the project.

3.0.1 Research Strategy

The research held with respect to this dissertation was an applied one, but not new. Rather, numerous pieces of previous academic research exist regarding Aviation and its effects on the environment, not only for India in specific, but also for other affected nationsinternationally. As such, the proposed research took the form of a new research but on an existing research subject.

3.0.2 Research method – Qualitative versus Quantitativetechniques.

In order to satisfy the objectives of the dissertation, a qualitative research was held. The main characteristic of qualitative research is that it is mostly appropriate for small samples, while its outcomes are not measurable and quantifiable. Its basic advantage, which also constitutes its basic difference with quantitative research, is that it offers a complete description and analysis of a research subject, without limiting the scope ofthe research and the nature of participant's responses.

However, the effectiveness of qualitative research is heavily based on the skills and abilities of researchers, while the outcomes may not be perceived as reliable, because they mostly come from researcher's personal judgments and interpretations. Because it is more appropriate for small samples, it is also risky for the results of qualitative research to be perceived as reflecting the opinions of a wider population.

Table 3: Features of Qualitative & Quantitative Research.

Qualitative research	Quantitative Research
The aim is a complete, detailed description.	The aim is to classify features, count them, and construct statistical models in an attempt to explain what is observed.
Researcher may only know roughly in advance what he/she is looking for.	Researcher knows clearly in advance what he/she is looking for.
Recommended during earlier phases of research projects.	Recommended during latter phases of research projects.
The design emerges as the study unfolds.	All aspects of the study are carefully designed before data is collected.
Researcher is the data gathering instrument.	Researcher uses tools, such as questionnaires or equipment to collect numerical data.
Data is in the form of words, pictures or objects.	Data is in the form of numbers and statistics.
Subjective – individuals' interpretation of events is important., uses participant observation, in-depth interviews etc.	Objective: seeks precise measurement & analysis of target concepts, e.g., uses surveys, questionnaires etc.
Qualitative data is 'richer', time consuming, and less able to be generalized.	Quantitative data is more efficient, able to test hypotheses, but may miss contextual detail.
Researcher tends to become subjectively immersed in the subject matter.	Researcher tends to remain objectively separated from the subject matter.

3.0.3 Research Approach.

The research approach that was followed for the purposes of this research was the inductive one. According to this approach, researchers begin with specific observation, which are used to produce generalized theories and conclusions drawn from the research. The reasons for occupying the inductive approach was that it considers the context where research effort is active, while it is also most appropriate for small samples that produce qualitative data. However, the main weakness of the inductive approach is that it produces generalized theories and conclusions based only on a small number of observations, thereby the reliability of research results being under question.

3.0.4 Data Collection Methods and Tools.

For the purposes of this research, in depth interviews were used. In depth interviews are personal and unstructured interviews, whose main aim is to research subject. The main advantage of personal interviews is that they involve personal and direct contact between interviewers and interviewees, as well as eliminate non-response rates. But interviewers need to have developed the necessary skill to successfully carry an interview. What is more, unstructured interviews offer flexibility in terms of flow of the interview, thereby leaving room for the generation of conclusions that were not initially meant to be derived regarding a research subject. However, there is the risk that the interview may deviate from the pre-specified research aims and objectives. As far as data collection tools were concerned, the conduction of the research involved the use of semi-structured questionnaire, which was used as an interview guide for the researcher. Some certain questions were prepared, so as for the researcher to guide the interview towards the satisfaction od research objectives, but additional questions were made/encountered during the interviews.

3.0.5 Questionnaire.

Some sample questions that were included in the semi-structured questionnaire were the following:

This Survey was Conducted on Airline and Airport Staff at the Chhatrapati Shivaji Mumbai International Airport (CSMIA). Staff Working for numerous organisations were a part of this. They ranged from various field from Engineering, Customer Service, Operations, Flight Crew, Ground Handling.

1. Does Aviation Burning contribute to global pollution? YES / NO

2. Do you think Aviation and Environment go hand in hand? YES / NO

3. Has your airport been impacted by more adverse weather events, patterns, and conditions? YES / NO

4. Do you expect impact from more adverse weather events, patterns, and conditions on your airport's infrastructure or operation in the coming 10 years? YES / NO

5. Has your airport or another local/national government conducted a climate change-related risk or vulnerability assessment? YES / NO

6. Do you think your country contributes or works enough towards the Environment, formulates policies to keep the organisations in check on their carbon footprint, encourages private NGOs to work effectively? YES / NO

7. In your daily work activities at the Airport both on the Airside and Landside how much are you affected by the Noise of the Engines? Rate ata scale of 1 to 10 with '1' being the least amount of effect and '10' being the most unbearable.

8. What do you think can be the new advancements in Air Travel that can make it more fuel efficient and eco-friendly at the same time? share any new technology you have heard or read about.

9. Do you think there can ever be a replacement to Aviation Turbine Fuel? YES / NO and if yes what will it be?

10. Names few of the travel options that are eco friendly and efficient compared to air travel?

11. If ever given the chance to govern the regulating authority India, what one change can you bring to the current scenario of Aviation in India?

3.0.6 Sample Selection.

The method of purposive sampling was used to develop the sample of the research under discussion. According to this method, which belongs to the category of non-probability sampling techniques, sample members are selected based on their knowledge, relationships and expertise regarding a research subject. In the current study, the sample members who were selected had special relationship with the phenomenon under investigation, enough and relevant work experience in the field of Aviation, active involvement in several Aviation initiatives and partnerships, as well as proven research background and understanding of raw data concerning the Environment. Within this context, the participants of this study wereexecutives of 6 famous Companies operating both generally in India and specifically inChhatrapati Shivaji Mumbai International Airport (CSMIA), namely:

- Directorate General of Civil Aviation (DGCA)
- Jet Airways
- Vistara
- Indigo
- Go Air
- Spicejet
- Celebi/NAS
- Bird Worldwide Flight Services (**BWFS**)

3.0.7 Research Process

Meetings were held during April, June and September of 2019 with the Staff of the DMOs mentioned above, to gain acceptance of their participation in the research. More specifically, I came in touch with and asked them to participate in the researchafter explaining the nature and the scope of the study. In general terms the respondents were willing to participate in the research and the interviews were conducted between May and September of 2019. The discussions took place at the offices or during breaks in the canteen or recreational areas of the executives and lasted approximately 10 to 15 minutes. During the interviews were mainly kept notes, in order to help the researcher to analyse the gathered data.

During the conduction of the interview, respondents were free to express them views even in topics which were not included in the discussed areas. Finally, it should be noted that the conversations flowed smoothly and pleasantly.

3.0.8 Data Analysis

Content analysis was used to analyse the data which was gathered from personal interviews. According to Moore & McCabe (2005), this is the type of research whereby data gathered is categorized in themes and sub-themes, to be able to be comparable. A main advantage of content analysis is that it helps in data collected being reduced and simplified, while at the same time producing results that may then measure using quantitative techniques.Moreover, content analysis gives the ability to researchers to structure the qualitative data collected in a way that satisfies the accomplishment of research objectives. However, human error is highly involved in content analysis, since there is the risk for researchers to misinterpret the data gathered, thereby generating false and unreliable conclusions (Krippendorff &Bock. 2008).

Chapter 4

4.0 Findings and Analysis.

National Safety Council of India (NSCI) identifies seven greenhouse gases that are responsible to monitor and regulate inorder to reduce emissions: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and nitrogen trifluoride (NF_3). The fluorinated gases are also referred to as "high global warming potential gases".

4.1 Descriptive Statistics

4.1.1 Carbon Dioxide CO_2

Airplanes could generate 43 gigatons of planet-warming pollution through 2050, consuming almost 5 percent of the world's remaining carbon budget, according to a new Government report. Aircraft emit staggering amounts of CO2, the most prevalent manmade greenhouse gas. In fact, they currently account for some 11 percent of CO2 emissions from Indian transportation sources and 3 percent of the India' total CO2 emissions.

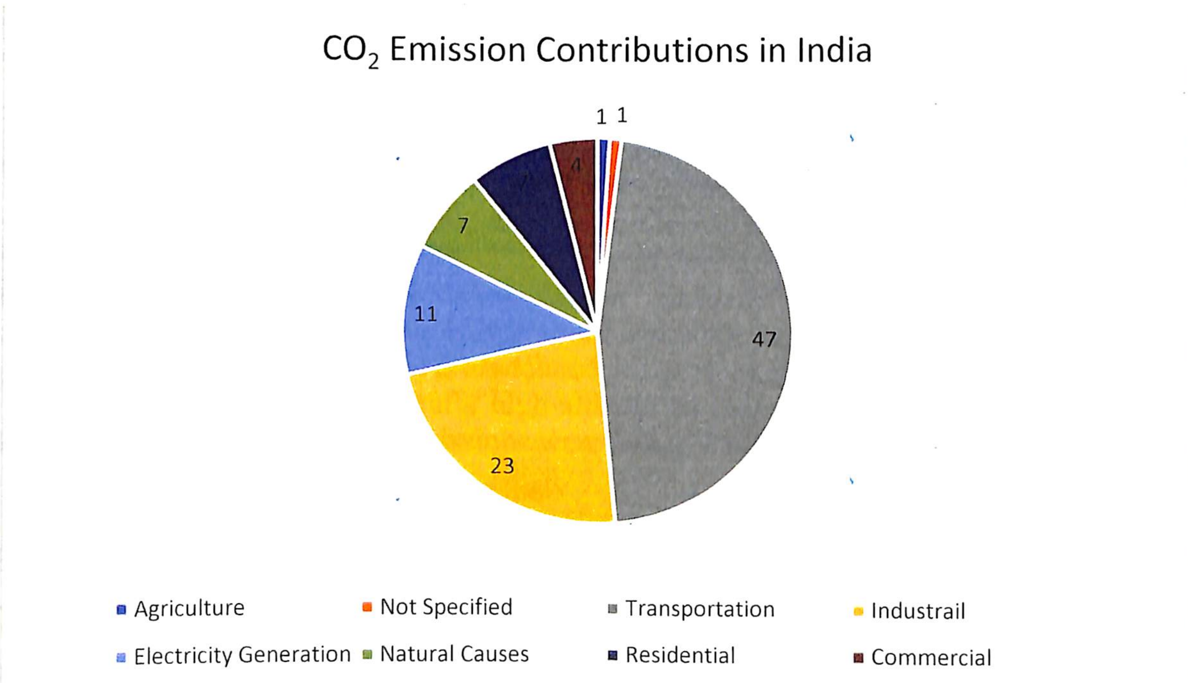

Illustration 6: Contributors of CO_2 in India Measured based on Research.

Transportation in India accounts for 47% of the Country's total CO_2 Emissions. With A population of One Billion Three Hundred Sixty-Six Million as of 2019, the need for a green transportation is a must. Transportation in India is Taken care of by Passenger cars, Busses, Trains, Trucks, Flights and other Public Means of Transport.

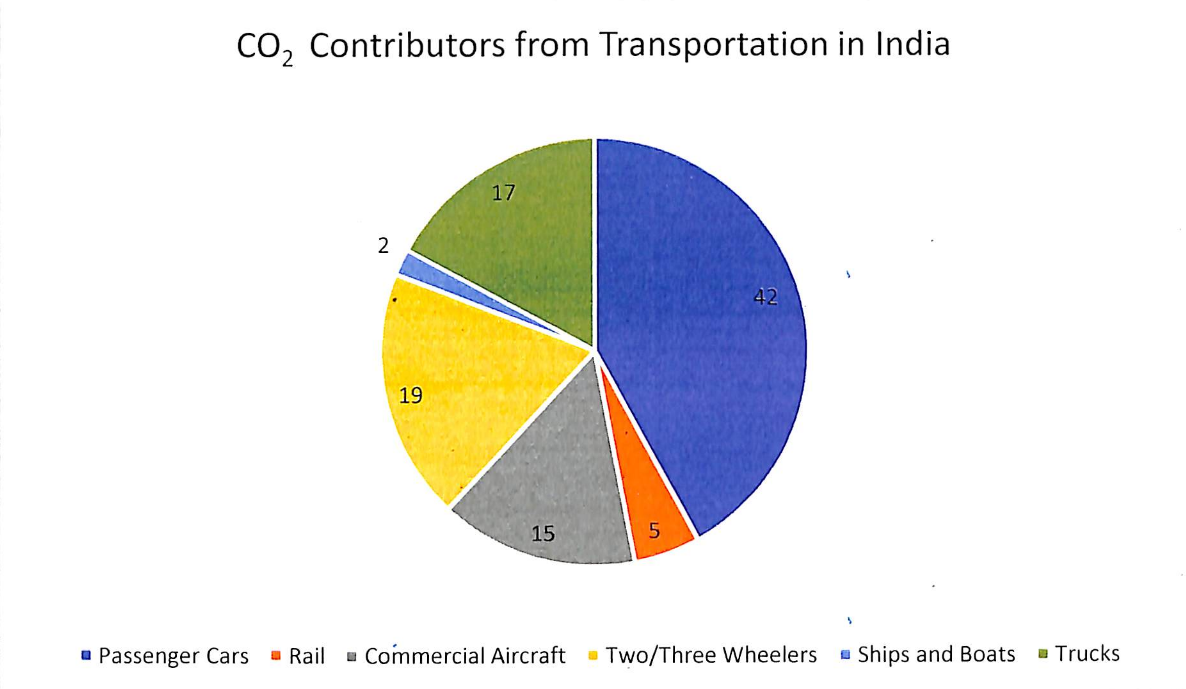

Illustration 7: CO_2 Contributors from Transportation in India Measured based on Research.

4.1.2 Nitrogen Oxides NO_X

In addition to CO2, aircraft emit nitrogen oxides, known as NOx, which contribute to the formation of ozone, another greenhouse gas. Emissions of NOx at high altitudes result in greater concentrations of ozone than ground-level emissions. Aircraft also emit water vapor at high altitudes, creating condensation trails or "contrails" — visible cloud lines that form in cold, humid atmospheres and contribute to the warming impacts of aircraft emissions. The persistent formation of contrails is associated with increased cirrus cloud cover, which also warms the Earth's surface. Aircrafts' high-altitude emissions have a greater global warming impact than they would if the emissions were released at ground level.

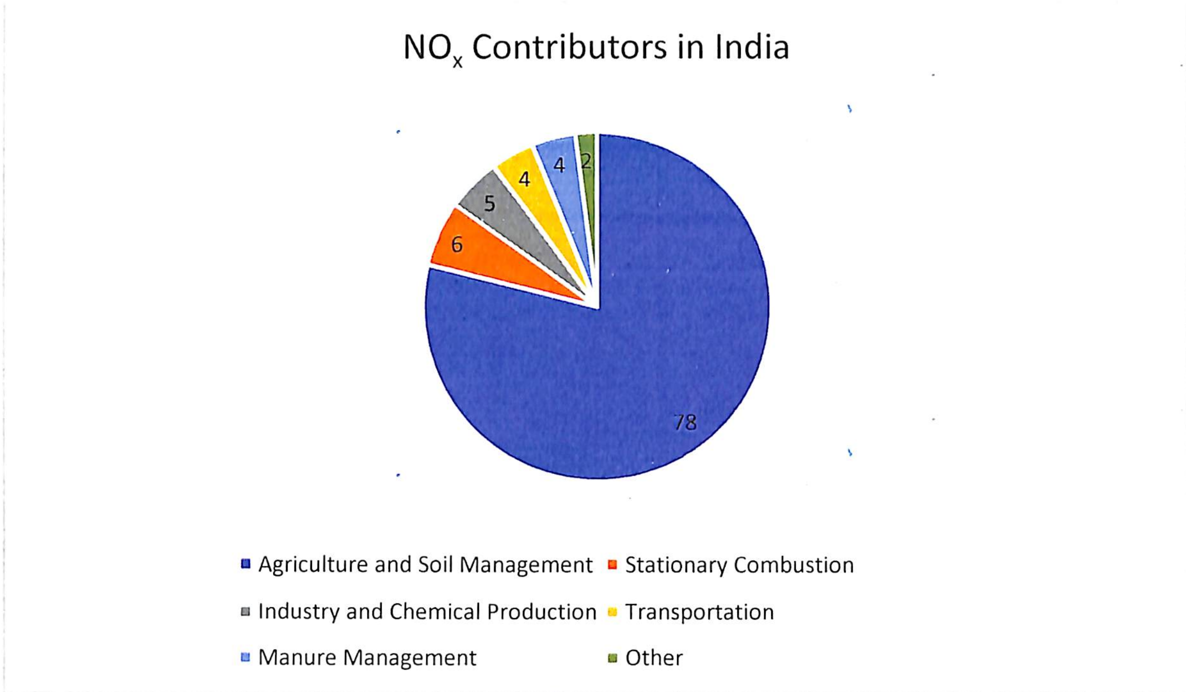

Illustration 8: NO_X Contributors in India based on Research.

Even Though Aircraft Emissions are low in the case of NO_X in India with the growing Rise in Population and Standard of living of people, it is surely going to rise soon. At the High altitudes flown by large jet airliners around the tropopause, emissions of NO_x are particularly effective in forming ozone (O_3) in the upper troposphere. High altitude (8–13 km) NO_x emissions result in greater concentrations of O_3 than surface NO_x emissions, and these in turn have a greater global warming effect. The effect of O_3 surface concentrations are regional and local, but it becomes well mixed globally at mid and upper tropospheric levels.

NO_x emissions also reduce ambient levels of methane, another greenhouse gas, resulting in a climate cooling effect. But this effect does not offset the O_3 forming effect of NO_x emissions. It is now believed that aircraft sulphur and water emissions in the stratosphere tend to deplete O_3, partially offsetting the NO_x-induced O_3 increases. These effects have not beenquantified. This problem does not apply to aircraft that fly lower in the troposphere, such as light aircraft or many commuter aircraft.

4.1.3 Water Vapour (H_2O), Contrails

One of the products of burning hydrocarbons with oxygen is water vapour, a greenhouse gas. Water vapour produced by aircraft engines at high altitude, under certain atmospheric conditions, condenses into droplets to form condensation trails, or "contrails". Contrails are visible line clouds that form in cold, humid atmospheres and are thought to have a global warming effect (though one less significant than either CO_2 emissions or NO_x induced effects). Contrails are uncommon (though by no means rare) from lower-altitude aircraft, or from propeller-driven aircraft or rotorcraft.

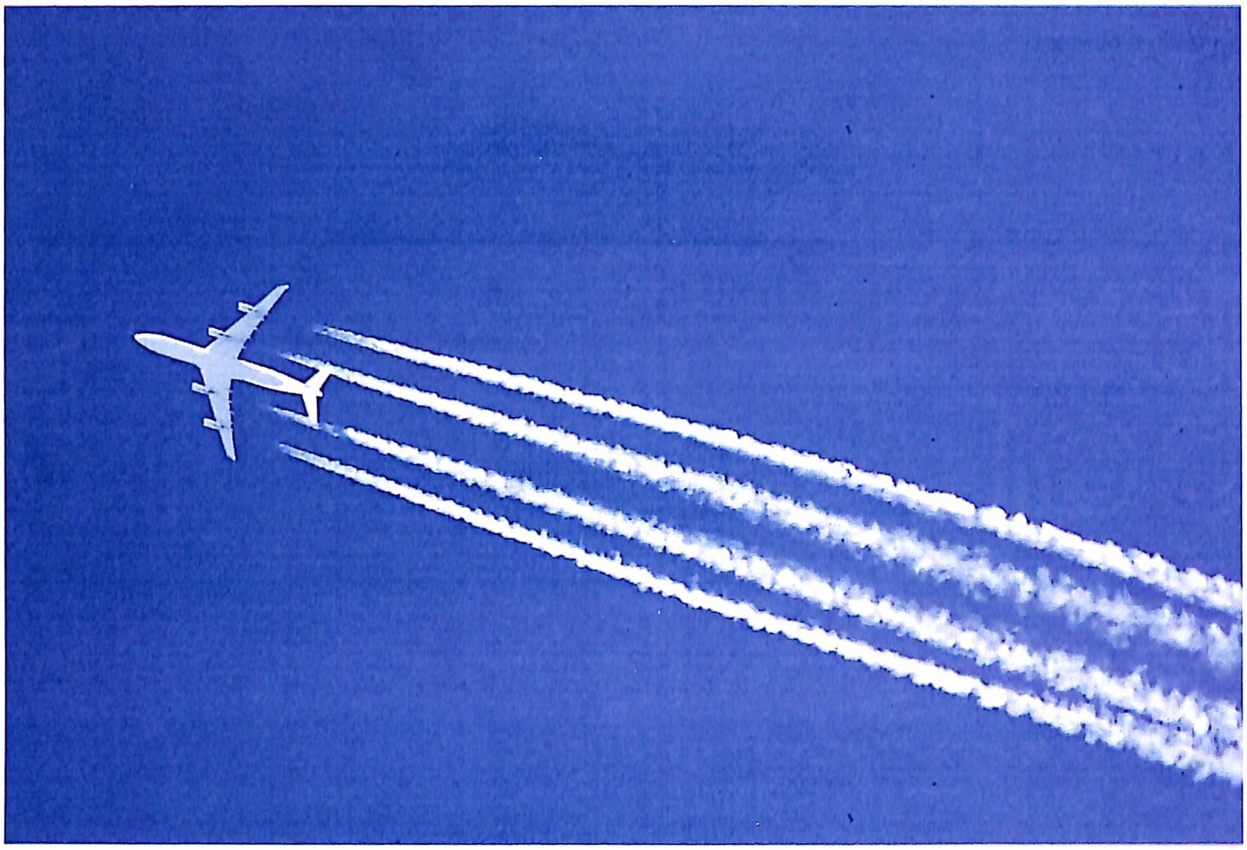

Illustration 9: Formation of Contrails behind a Boeing 747 Aircraft.

Cirrus clouds have been observed to develop after the persistent formation of contrails and have been found to have a global warming effect over-and-above that of contrail formation alone. There is a degree of scientific uncertainty about the contribution of contrail and cirrus cloud formation to global warming and attempts to estimate aviation's overall climate change contribution do not tend to include its effects on cirrus cloud enhancement. However, a 2015 study found that artificial cloudiness caused by contrail "outbreaks" reduces the difference between daytime and night-time temperatures. The former is decreased, and the latter are increased, in comparison to temperatures the day before and the day after such outbreaks. On days with outbreaks the day/night temperature difference was diminished by about 6 °F in the southern US and 5 °F in the Midwest.

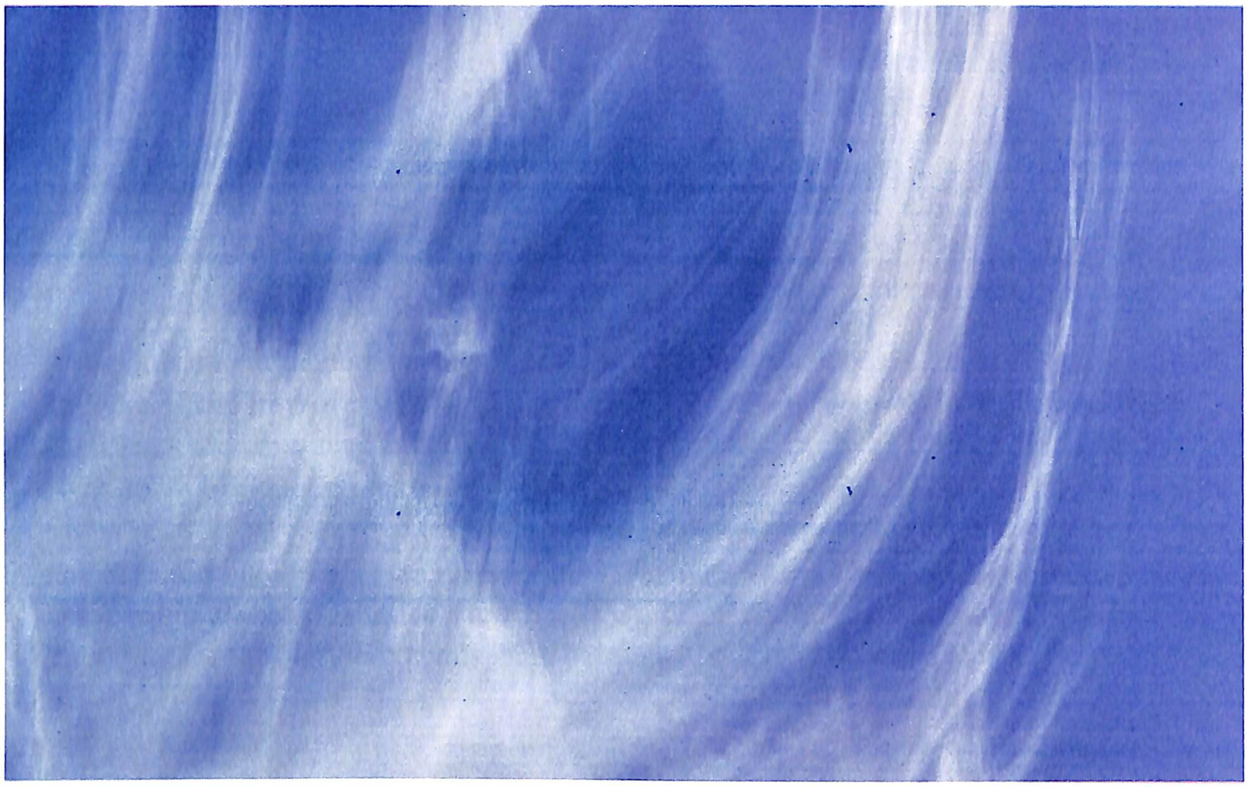

Illustration 10: Cirrus Cloud formation.

4.1.4 Particulates

Least significant on a mass basis is the release of soot and sulphate particles. Soot absorbs heat and has a warming effect; sulphate particles reflect radiation and have a small cooling effect. In addition, particles can influence the formation and properties of clouds, including both line-shaped contrails and naturally occurring cirrus clouds. The impact of "spreading contrails and cirrus clouds that evolve from them—collectively known as contrail cirrus—have a greater radiative forcing (RF) today than all aviation CO_2 emissions since the first powered airplane flight". Of the particles emitted by aircraft engines, the soot particles are thought to be most important for contrail formation since they are large enough to serve as condensation nuclei for water vapor. All aircraft powered by combustion will release some amount of soot; although, recent studies suggest that reducing the aromatic content of jet fuel decreases the amount of soot produced.

Chapter 5

5.0 Interpretation of Results.

Aviationis one of the most dynamic sectors of the global economy.Technological andoperational improvements lag its growth. The consequence will be a sustained and significant increase in emissions for the foreseeable future ($CO2$ 3.3 - 13-fold increase, NOX 2.7 - 7-fold increase by 2050). The radiative forcing of aviation may rise by a factor of 4 - 12 by 2050 compared to 1992. Aviation may be responsible for 5% - 15% of radiative forcing in 2050, compared with 3.5% today (and this forecast is a lower bound because not all potential effects are included). The threat of climate change is more important for the Northern hemisphere because of changes in ozone concentration.

5.0.1 Investment in new technology and in modern aircraft - is the need of the hour.

The industry's competitive environment is undergoing fundamental change. Its development in major markets is constrained by problems caused by overloaded airport and air traffic control systems and by concern about air transport's environmental impact. To meet growing demand, the industry must invest heavily in new technology and in modern aircraft. The airlines must improve based on outstanding standards of safety, efficiency and reliability and must continually reduce costs to the consumers. At the same time, the industry must constantly seek to reduce its environmental impact and should considerably improve its environmental performance over time.

5.0.2 Technology based environmental performance

Environmental impacts will increase with the volume of air traffic rising, albeit at a slower pace. But future growth is likely to depend on further reductions in the environmental impact of airline operations. Quiet apart from the major question of the ability of the airways and airports to absorb traffic growth, air transport will need to further reduce its environmental impact whilst improving its environmental performance. If air transport's impact on the environment is to be minimized, the industry must continually devote adequate resources to improve its environmental performance and should fully exploit the best available technology.

5.0.3 Environmental review

Environmental review is required for the actions in connection with proposed airport development. Major environmental assessment issues can be simplified by division into two categories; operational impacts those issues related to patterns of aviation operational activity and thus driven by changes in aircraft design, airport capacity, and air traffic management; and geographical impacts those issues related to the size, dimension, and placement of airport facilities that may result in effects on natural resources including wetlands, floodplains, flora and fauna.

5.0.4 Curbing the Air Transportation

Aviation is a critical part of our national economy, providing for the movement of people and goods throughout the world, enabling our economic growth. In the last 40 years there has been a six-fold increase in the mobility provided by the air transportation system compelling the urgent need to address the environmental effects of air transportation. Because of the strong growth in demand, emissions of some pollutants from aviation are increasing against a background of emissions reductions from many other sources. In addition, progress on noise reduction has slowed. Millions of people are adversely affected by these side effects of aviation. As a result of these factors and the rising value being placed on environmental quality, there are increasing constraints on the mobility, economic vitality and security. Airport expansion plans have been delayed or cancelled due to concerns over local air quality, water quality and community noise impacts. Military readiness is challenged by restrictions on operations. These effects are anticipated to grow as the economy and demand for air transportation grow due to the Indian government's initiative in welcoming the concept of liberalization, privatization and globalization. If not addressed, environmental impacts may well be the fundamental constraint on air transportation growth in the 21^{st} century.

5.0.5 Green Taxation

The author suggests that despite various regulatory framework or programmes or policies initiated by the government, the menace of curbing the environmental issues can't be curtailed unless a need for environmental taxes is initiated. Nowadays, environmental concerns are increasingly being brushed aside and replaced by the rapidly growing need for development. Hence, the author raises a pertinent question at this juncture, i.e. as to what is the need for environmental taxes? How do they help? What purpose do they serve? Green taxation is actually a multi-pronged tool in the hands of the government, which helps tackle the menace of growing unsustainable lifestyle practices and environmental degradation in more ways than one i.e. they provide incentives to lessen environmental burden and preserve the environment; revenues generated by environmental taxes can be used for other environmental preservation projects or to cut other taxes; a pure environmental tax aims to ensure that polluters face the true cost of their activities by charging them for the damage caused to others; cost-effective because they ensure that pollution reductions are undertaken by those who can do most cheaply; subsidies for emissions reductions do not have the same effect as emissions taxes; can provide significant incentives for innovation, as firms and consumers seek new, cleaner solutions in response to the price put on pollution etc.

5.0.6 Airports Vicinity Zone

Airports should be treated as Airport Vicinity Zone instead considering it under the industrial area due to frequent aircraft movements. Most of the airports worldwide have defined a Revision 1, dated 14th July 2011 separate category known as "Airport Vicinity Zone" wherein the ambient noise levels are much higher than any other category of noise levels due to aircraft operation.

5.0.7 Role of Air Traffic Controllers

Aviation in terms of environment cannot be neglected nor be given a second priority. There needs to be a harmony between flying machines and the nature. Even a slightest of the savings can bring do good to the environment. Air Traffic Controllers improvements could allow for a reduction in fuel consumption and due to military airspace, there is a deviation that leads to more fuel burn.

5.0.8 Biofuel

A fresh thrust for Greener Flights; every day and every second an aircraft lands or takes-off somewhere in the world. This being a continuous process again generates concern over greenhouse gas emissions. Even though the aviation's share in the greenhouse gas is little, it is adding more to the atmosphere. As air travel is increasing more ground-based airport vehicles, are switching gears on to the biofuels like ethanol and Biodiesel.The aviation sector has identified the scope and development of bio-fuels as one of the major ways of reducing greenhouse gas emissions. Even though it is partially at present, but one day it will be complete.

5.0.9 Addressing the independent challenges

The author stresses for a significant research program to assess the potential impacts of aviation on climate, if not this may put India at a disadvantage in evaluating technological, operational and policy options, and in negotiating appropriate regulations and standards with other nations. The international concerns will continue to grow with the strong increase in air transportation demand anticipated in Asia. Immediate, focused action is required to address the interdependent challenges of aviation noise, local air quality and climate impacts. Not acting, as stated above, will not only affect millions of people living near airports but will adversely impact the vitality and security of a nation. A national vision and strategic plan of action are required.

However, the challenges and issues faced by the Indian Aviation industry in respect to environmental issues are; infrastructural woes; rising Airline Turbine Fuel (ATF) Prices; Congestion etc.

5.1Comparison of Results with Assumptions (Hypotheses)

There were several Research Hypothesis that were drawn at the start of this study.

Hypothesis. 1: "Public are not aware of the legal aspects of environment".
Hypothesis. 2: "Aviation industry is more profit based rather than being mindful of their activities and how they will affect the future".
Hypothesis. 3: "NGOs are not publicizing or enhancing their environmental awareness programmes to the mass"
Hypothesis. 4: "There is currently no mode of transport in the world that is as fast and as time efficient as the Aviation Industry.

5.1.1 Hypothesis. 1: "Public are not aware of the legal aspects of environment".

The need for protection and conservation of environment and sustainable use of natural resources is reflected in the constitutional framework of India and in the international commitments of India. The Constitution under Part IVA (Art 51A-Fundamental Duties) casts a duty on every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife, and to have compassion for living creatures. Further, the Constitution of India under Part IV (Art 48A-Directive Principles of State Policies) stipulates that the State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country.

Several environment protection legislations existed even before Independence of India. However, the true thrust for putting in force a well-developed framework came only after the UN Conference on the Human Environment (Stockholm, 1972). After the Stockholm Conference, the National Council for Environmental Policy and Planning was set up in 1972 within the Department of Science and Technology to establish a regulatory body to look after the environment-related issues. This Council later evolved into a full-fledged Ministry of Environment and Forests (MoEF).

MoEF was established in 1985, which today is the apex administrative body in the country for regulating and ensuring environmental protection and lays down the legal and regulatory framework for the same. Since the 1970s, several environment legislations have been put in place. The MoEF and the pollution control boards ("CPCB", i.e., Central Pollution Control Board and "SPCBs", i.e., State Pollution Control Boards) together form the regulatory and administrative core of the sector.

Some of the important legislations for environment protection are as follows:

- The National Green Tribunal Act, 2010
- The Air (Prevention and Control of Pollution) Act, 1981
- The Water (Prevention and Control of Pollution) Act, 1974
- The Environment Protection Act, 1986
- The Hazardous Waste Management Regulations, etc.

5.1.2 Hypothesis. 2: "Aviation industry is more profit based rather than being mindful of their activities and how they will affect the future".

Aviation is one of the fastest-growing sources of greenhouse gas emissions globally and currently it contributes to 2% of overall anthropogenic Greenhouse Gas (GHG) Emission (Intergovernmental Panel on Climate Change (IPCC), 2004). The International Civil Aviation Organization's (ICAO) 2016 Environmental Report (On Board A Sustainable Future2)states that changes to the atmosphere, brought about by rising global temperatures caused by greenhouse gas emissions, will affect airplane's ability to fly, while rising sea levels will affect airports.

ICAO has warned that the aviation industry needs to prepare for severe disruptions as a result of climate change and that it needs to make full use of clean technology and policy tools in order to reduce its carbon footprint along with other environmental impacts. Exploring the use of bio jet fuels, energy efficient infrastructure, electric vehicle, green taxiing vehicle etc. proper regulatory frameworks and favourable market conditions will help in Aviation GHG reduction.

Aircraft noise near airports poses major health and environmental risk raising public concerns and is likely to impact future operations, as well as expansion and development of airports. The aviation stakeholders are consistently working together to reduce the noise impact through technology, process improvement and land use planning. However, the noise impact around airports may be significantly reduced by proper land use planning, which needs to be addressed collectively with government stakeholders.

The development and operation of an airport causes gaseous and particulate emissions from different sources including aircraft operations, ground support equipment, airport infrastructure and landside access traffic. Increased level of air pollution in certain states of India may result in operational constrains and reduced international travels and tourism; it may also lead to low visibility situations around the airport.

Effective land use planning around the airports in cooperation with Development Agencies, Authorities, Public Transport Departments, and Metro Rail Corporations etc. with a focus on enhanced connectivity to Airport and dedicated services to airport will enable smooth airport operations with reduced environmental footprints and will be beneficial for sustainable aviation.

Increased infrastructure development supported by growth of civil aviation in India has raised a growing concern on resource consumption by the aviation sector. There is a strong need for all the stakeholders to adopt resource conservation measures, green building concept, etc.

Waste Management by municipal bodies around the airports is also one of the concern areas for airport & aircraft operation. Improper waste management leads to bird attraction which is a threat for aircraft operation at airport. There is a strong need for all the concerned agencies to ensure proper waste management around the airports.

The lengthy and complex process of obtaining Environment clearance of airport projects (new and expansion) sets back the developmental activities which are required to cater to the needs of the rapidly growing aviation sector of the country. The Ministry along with Central and State Govt. bodies, need to work collaboratively for simplification of these processes to ensure timely completion of developmental activities with due care to environment and sustainability.

Recognizing the fact that Indian aviation sector would have exponential growth, addressing the environment and sustainability concerns are very important. To overcome the above stated concerns and address these issues, the need for a Green Civil Aviation Policy has been envisaged with a clear objective of achieving sustainable growth of the civil aviation.
MoCA along with the key aviation stakeholders conducted stakeholder meetings and formulated a task force and working groups to deliberate on the requirement of a National Green Civil Aviation Policy. The task force and working groups include representative from Ministry of Civil Aviation (MoCA), Ministry of Environment Forest & Climate change (MoEF&CC), Ministry of Petroleum & Natural Gas (MoP&NG), Directorate General of Civil Aviation (DGCA), Airport Operators, Airlines, Air Navigation Services (ANS), Ground handling agencies and The Energy & Resources Institute (TERI). The inputs from the members of Task force, working groups and stakeholders were obtained through meetings, brainstorming sessions and questionnaires. Based on the responses received from various stakeholders the White Paper on National Green Civil Aviation Policy has been outlined.

5.1.3 Hypothesis. 3: "NGOs are not publicizing or enhancing their environmental awareness programmes to the mass"

Today we come across various non-governmental organizations whose concerns are focused on various areas such as social issues, health issues and environmental issues. Non-governmental organization is a broad term, which includes charity organizations, advisory committees and various other professional organizations. NGOs in India are spread across the country and they have close contacts with communities.
They are involved in the whole spectrum of developmental activities from creating environmental awareness to undertaking watershed development: from disaster management to sustainable livelihoods; from joint forest management to giving inputs to policies. They range from clubs, which encourage nature camping to agencies, which undertake research and monitoring.
There are large number of NGOs in India and other countries that are exclusively working for environmental protection, conservation and awareness. The number of these non-governmental organizations which are actively involved in environmental protection in our country is in fact more than in any of the other developing countries. Increasingly, the government is viewing NGOs not only as agencies that will help them to implement their programs, but also as partners shaping policy and programs.
NGOs are now playing an important role in framing the environmental policy, mobilizing public support for environmental conservation and protecting the endangered species of forests and animals. Environmental organizations such as earth watch and sea shepherd conservation society have been successful in creating awareness about the environmental dangers in using drift nests in commercial fishing industry.
Through driftnet monitoring, public education and action they were successful in banning drift-nets system internationally. The issues like future of environmental protection, sustainable development and zero population growth are some of the major concerns of the environmental NGOs

Environmental policies will; achieve positive results only when they are addressed to local issues and solve the problem of local people. The policymakers should keep in mind the needs of the people while framing the policies and implementing the environmental-friendly projects.
Unless the needs of the people are identified and supported, sustainable development cannot be achieved. Policy makers and administrators should take care in selecting, financing and implementing projects, which are aimed at promoting social welfare. They should not encourage the enterprises that promote private ownership and cooperation.
Some of the international environmental organizations are Greenpeace, worldwide fund for nature (WWF). Earth first, etc.

5.1.4 Hypothesis. 4: "There is currently no mode of transport in the world that is as fast and as time efficient as the Aviation Industry".

A fixed-wing aircraft, typically airplane, is a heavier-than-air flying vehicle, in which the special geometry of the wings generates lift and then lifts the whole vehicle. Fixed-wing aircraft range from small trainers and recreational aircraft to large airliners and military cargo aircraft. For short distances or in places without runways, helicopters can beoperable. (Other types of aircraft, like autogyros and airships, are not a significant portion of air transport.)

Air transport is the fastest method of transport, Commercial jets reach speeds of up to 955 kilometres per hour (593 mph) and a considerably higher ground speed if there is a jet stream tailwind, while piston-powered general aviation aircraft may reach up to 555 kilometres per hour (345 mph) or more. This celerity comes with higher cost and energy use, and aviation's impacts to the environment and particularly the global climate require consideration when comparing modes of transportation. The Intergovernmental Panel on Climate Change (IPCC) estimates a commercial jet's flight to have some 2-4 times the effect on the climate than if the same CO_2 emissions were made at ground level, because of different atmospheric chemistry and radiative forcing effects at the higher altitude. U.S. airlines alone burned about 16.2 billion gallons of fuel during the twelve months between October 2013 and September 2014. WHO estimates that globally as many as 500,000 people at a time are on planes? The global trend has been for increasing numbers of people to travel by air, and individually to do so with increasing frequency and over longer distances, a dilemma that has the attention of climate scientists and other researchers, the press, and the World Wide Web. The issue of impacts from frequent travel, particularly by air because of the longer distances that are easily covered in one or a few days, is called hypermobility and has been a topic of research and governmental concern for many years.

Modern aircraft consume less fuel per person and mile travelled than cars when fully booked. This argument in favour of air travel is counterweighted by two facts:

1. The distances travelled are often significantly larger and will not replace car travel but instead add to it, and
2. Not every flight is booked out.

Instead, the scheduled flights are predominant, resulting in a far worse fuel efficiency. According to the ATAG (Air Transportation Action Group), flights produced 781 million tonnes (769 million long tons) of the greenhouse gas CO2 in 2015 globally, as compared to an estimated total of 36 billion tonnes (35 billion long tons) anthropogenic CO_2. Carbon offset is often proposed as solution to mitigate the CO_2 emissions of flying. There are many NGO's that offer to compensate CO_2 emissions by advancing clean renewable energy, reducing energy consumption and capturing already released carbon in trees or other plants. However, carbon offsetting is a very controversial topic as it only tries to mitigate what has already been emitted.

Chapter 6

Conclusions and Scope of Future Work

6.1 Conclusions

The growth of aviation and its local and global impacts has created serious problems that must now be resolved. The publication in late 1999 of the United Nations review of the global environment (UNEP, 1999) showed just how serious these problems are. It would be perverse and contrary to UK and EU sustainable development policy not to find a way that can manage the impacts of aviation within a framework that reduces growth, reduces impacts and protects health and environment. We have shown that there are several ways in which this can be done. Aviation is not an example of the intractable international industry that cannot be part of the solution. The development of demand management in aviation should be associated with a full package of measures:

• An environmental charge based on emissions
• The ending of all subsidies and tax exemptions
• More stringent noise and emission standards for aircraft and for geographical areas around airports
• More research and best practice guidance on substitution
• Better levels of local environmental data and environmental monitoring to inform local populations about air and noise quality

These measures should be introduced in an incremental fashion to give the industry and consumers time to adjust to the changes. Incrementalism is already built into the environmental charge but will need development in the area of standards.

Education and awareness are very important indeed in aviation. There will be many airline customers who have never thought of airports and flying as an environmental problem. Information should be widely available so that these groups have the background information they need to understand the changing circumstances of aviation. Informed choice is a key component of transport demand management and environmental policy.

The latest scientific evidence on the state of the global environment (UNEP, 1999) and on the contribution of aviation to global inventories of greenhouse gases reviewed in this report point to the need for a fundamental change in public policy towards aviation. The current impact of aviation and the forecasts of future impacts bring into sharp focus the need for a policy that is based on science and that can bring about a re-positioning of aviation within the context of sustainable development and overall environmental objectives. The science is clear, the policy measures that are available are clear. All that remains to be put in place is a clear aviation policy.

Air quality and noise are likely to remain the central operational impact issues in environmental documentation into the new millennium, although the discussion of these concerns will undergo change in terms of both types of impacts considered and methods of evaluation. Similar changes are probable in the discussion of other operational impacts, including surface vehicle traffic, social and economic effects, and energy supply. The assessment of geographical impacts will also be subject to new considerations in the future. However, the new millennium also might see recognition of the environmental benefits generated by airports. Because of their size, their location requirements (flat terrain), and their proximity to population centres that historically developed adjacent to lakes, rivers, and oceans, airports have the potential to function as preserves or conservation areas for natural resources that may be threatened by development "beyond the fence." Even now, perhaps inadvertently, managers of large air carrier airports in urban areas might find themselves effectively serving as custodians of special-status species (plant and animal), remnant landscape units, rare geological formations, wetlands of various types, aquifers, and surface water bodies. In some cases, important natural resources may present conflicts with an airport's functions, hence the problem at times encountered in environmental documentation in which mitigation requirements to restore or replace filled wetlands on an airport must be balanced with operational safety concerns associated with the location of natural features that attract birds in proximity to active runways. In other cases, airports may serve as protected oases for scarce and threatened natural resources within the densely developed urban region without compromise of their operational requirements. Environmental documentation in the future may include more detailed assessment of the ecological benefits provided by airports as well as of the ecological costs of development at airports. Advances in technology are the primary catalysts that have transformed aviation since its infancy 96 years ago. The modern airport is pushing its capacity limits because of demand—demand driven by economics, larger and more efficient aircraft, and improvements in navigation, safety, and communications. The new millennium will inevitably bring even larger, faster, higher-flying aircraft that will carry more passengers and more cargo and require airport development—runways, taxiways, terminals, and roads—all with known and maybe some unknown environmental impacts. New advances will require continued research into the state-of-the-art environmental assessment issues discussed here and others yet to be discovered.

6.2 Scope for Future Work

6.2.0 A Framework for National Goals

A set of clear, measurable goals for long-term environmental improvement is necessary to support the National Vision. Within the limited scope of this study, we did not address such goals. However, we offer the following as a potential framework for their development. One of the first activities of the federal interagency group for aviation and the environment that we propose in Section 6.1 should be to develop and finalize these goals. In doing so, the following guidelines should be considered. We have divided these guidelines into three parts: recommendations on the process of defining and reviewing the national goals, recommendations on the metrics (i.e., how progress will be measured), and recommendations on the goals themselves.

6.2.1 Processes

- The metrics and goals should be developed through an open, inclusive process involving a broad cross-section of stakeholders.

- The goals and metrics should be related to representative examples to enable communication with non-experts.

- As part of the process for establishing the goals, a schedule for periodic review of both metrics and goals should be established. When improved metrics are developed, they may merit incorporation. If conditions change, and when uncertainty regarding impacts improves, the goals may need to be revised.

- A periodic process should be established for assessing progress against the goals and communicating that progress to the stakeholders.

6.2.2 Metrics

- The goals should incorporate the best available metrics. When there is concern that the metrics do not accurately reflect the health and welfare impacts, it is important to move forward with existing metrics, but also to plan specific actions for improving the metrics.

- To measure progress relative to the national vision, metrics should be defined based upon specific health and welfare endpoints (e.g., quantitative health and welfare risks due to local air quality impacts of aviation).

- However, supplemental metrics involving quantities of pollutant or efficiency metrics could be used to relate the national goals to other significant policy or regulatory benchmarks.

- For areas where there is considerable uncertainty as to aviation's effects (e.g., climate change, HAPS and PM), the metric employed should be the uncertainty in assessing impacts. This will enable specific quantitative goals to be set with regard to reductions in uncertainty (e.g., reduce uncertainty in the climate change impacts of aviation from ±100% to ±25% over 10 years).

6.2.3 Goals

- The goals should be both meaningful (accurately representing the national vision for absolute reductions in significant impacts), and achievable (with due consideration for economic reasonableness and technological feasibility).

- The goals should be established in a framework that allows for consideration of interdependencies. For example, the goals could be formulated as ranges, rather than single values, to reflect the interdependent nature of the environmental impacts of aviation and the range of approaches that may be employed to mitigate them; progress in one domain may limit progress in another.

- The goals should clearly define a threshold level for significance as referenced in the National Vision Statement ("In 2025, significant health and welfare impacts ... will be reduced in absolute terms").

- The goals should specify the baseline against which change will be measured.

Bibliography

Aviation Environment Federation, "Economic Screening of Aircraft Preventing Emissions," Prepared by CE Delft, August 2000.

Dobbie, L., "Air Transport: A Global Approach to Sustainability," International Air Transport Association, Geneva, Switzerland, 1999, URL: http://www.sustdev.org/journals/edition.02/ download/sdi2_1_12.pdf, [accessed July 2004].

Environmental Protection Agency, "Evaluation of Air Pollutant Emissions from Subsonic Commercial Jet Aircraft," EPA 420-R-99-013, Engine Programs and Compliance Division, Office of Mobile Sources, Ann Arbor, MI, prepared by ICF Consulting Group, April 1999.

Federal Interagency Committee on Aviation Noise, "Aviation Noise Research Conducted by FICAN Member Agencies," Prepared for the FAA by Harris, Miller, Miller and Hanson, Inc. August 1998, URL: http://www.fican.org/download/resear98.pdf, [accessed July 2004].

Federal Transportation Advisory Group, "Vision 2050, An Integrated Transportation System," February 2001, URL: http://www.commutercars.com/downloads/studies/DOTVision2050.pdf, [accessed July 2004].

General Accounting Office, "Aviation and the Environment, FAA's Role in Major Noise Programs," Report to Congressional Requesters, GAO/RCED-00-98, Washington, DC, April 2000, URL: http:// www.gao.gov/archive/2000/rc00098.pdf, [accessed July 2004].

General Accounting Office, "Aviation Infrastructure, Challenges Associated with Building and Maintaining Runways," Testimony before the Subcommittee on Aviation, Committee of Transportation and Infrastructure, House of Representatives, GAO-01-90T, Washington, DC, October 2000, URL: http://www.gao.gov/archive/2000/d010090t.pdf, [accessed July 2004].

International Civil Aviation Organization, "Consolidated Statement of Continuing ICAO Policies and Practices Related to Environmental Protection," Assembly Resolution A33-7, 2001, URL: http:// www.icao.int/cgi/goto_atb.pl?icao/en/env/overview.htm;env, [accessed July 2004].

International Civil Aviation Organization, "Report of the Committee on Aviation Environmental Protection," Fifth Meeting, Montreal, Canada, January 2001.

International Civil Aviation Organization, "Report of the Committee on Aviation Environmental Protection," Sixth Meeting, Montreal, Canada, February 2004.

Lee, H.; Wang, W., "Environmental Impacts and Policy Options for Aviation: Taiwan's Responses within the Global Framework, Terrestrial, Atmospheric and Oceanic Sciences," [TAO] Vol. 12, no. 1, pp. 195-208, Mar 2001.

National Research Council, "Aeronautical Technologies for the Twenty-First Century," Committee on Aeronautical Technologies, Aeronautics and Space Engineering Board, Washington, DC, 1992, URL: http://books.nap.edu/catalog/2035.html, [accessed July 2004].

National Research Council, "Atmospheric Effects of Aviation: A Review of NASA's Subsonic Assessment Project," Panel on Atmospheric Effects of Aviation, Board on Atmospheric Sciences and Climate, Washington, DC, 1999, URL: http://books.nap.edu/catalog/6409.html, [accessed July 2004].

National Research Council, "Atmospheric Effects of Aviation: A Review of NASA's Atmospheric Effects of Stratospheric Aircraft Project," Panel on Atmospheric Effects of Aviation, Board on Atmospheric Sciences and Climate, Washington, DC, 1999, URL: http://books.nap.edu/catalog/9604. html, [accessed July 2004].

National Research Council, "Research Priorities for Airborne Particulate Matter, IV: Continuing Research Progress," Committee on Research Priorities for Airborne Particulate Matter, Board on Environmental Studies and Toxicology, Washington DC, March 2004, URL: http://www.nap.edu/ books/0309091993/html/, [accessed July 2004].

Pew Centre on Global Climate Change, "Taking Climate Change into Account in US Transportation, Innovation Policy Solutions to Global Climate Change," In Brief #6, 2003, URL: http://www. pewclimate.org/docUploads/ustransp%5Fbrief%2Epdf, [accessed July 2004].

Reilly, J., Jacoby, H., Prinn, R., "Multi-gas Contributors to Global Climate Change: Climate Impacts and Mitigation Costs of Non-CO2 Gases," Massachusetts Institute of Technology, prepared for the Pew Centre on Global Climate Change, Arlington, VA, February 2003., URL: http://www.pewclimate. org/docUploads/Multi%2DGas%2Epdf, [accessed July 2004].

Strategic Aviation Special Interest Group, "The Impacts of Future Aviation Growth in the UK," A report for SASIF by Berkeley Hanover Consulting, London, UK, December 2000, URL: http://www. sasig.org/pdfs/tech/impact.pdf, [accessed July 2004].

United Kingdom Department for Transport, "Aviation and the Environment: Using Economic Instruments," London, UK, 2003, URL: http://www.hm-treasury.gov.uk/media//8E752/Aviation_ Environment.pdf [accessed July 2004].

United Kingdom Department for Transport, "The Future of Air Transport," London, UK, December 2003, URL: http://www.dft.gov.uk/aviation/whitepaper/main/index.htm, [accessed July 2004].

United Nations Framework Convention on Climate Change, 1992, URL: http://unfccc.int/resource/ conv/index.html, [accessed July 2004].

United Nations Kyoto Protocol, Adopted at the third session of the Conference of the Parties to the UNFCCC, Kyoto, Japan, December 1997, URL: http://unfccc.int/resource/convkp.html#kp, [accessed July 2004].

Wit, R., Dings, J., Mendes de Leon, P., Thwaites, L., Peters, P., Greenwood, D., and Doganis, R., "Economic Incentives to Mitigate Greenhouse Gas Emissions from Air Transport in Europe," CE Delft, July 2002.

References

Airports Policy Consortium (1997) Efficiency and Equity, Policy Paper 1, Surrey UK

Airports Policy Consortium (1999) "Contribution of the Aviation Industry to the Economy of the UK: a Response to Oxford Economic Forecasting"

Benell, D.W. and Prentice, B.E. (1993) A regression model for predicting the economic impacts of Canadian airports Logistics and Transportation Review 29, 139-158

Brockhagen, D and Lienemeyer, M (1998) Proposal for a European Aviation Charge. Design and implementation with respect to international economical, ecological, legal and political constraints

CE (1998) A European Aviation Charge. Feasibility Study, A Bleijenberg and R C N Wit, Centre for Energy Conservation and Environmental Technology, Delft, Netherlands

CIB (1998) Construction and the Environment, CIB World Building Congress, Gavle, Sweden,

EIB (1998) Annual Report 1998, European Investment Bank, Luxembourg

Environment Protection Agency (1993) Estimation and evaluation of cancer risks attributable to air pollution in SW Chicago, EPA, Washington DC, USA

Eur-Op News (1998) Transport Policy, 3/98; www.eur-op.eu.int/opnews/398/en/r354.htm

European Environment Agency (1995) Europe's Environment. The Dobris Assessment. European Environment Agency, Copenhagen

European Commission (1995) Towards fair and Efficient pricing in Transport: policy options for internalising the external costs of transport in the European Union, COM (95) 691

European Commission (1996) Towards fair pricing in Transport, COM (96) 331, Luxembourg

HACAN News (1997) Noise expert admits data out of date and unreliable, December

Henegar, M.K. (1994) Airport retailing is about to take off, Real Estate Review 23 (4) 57-61

Hepworth, M and Ducatel, K (1992) Transport and the information age, Belhaven, London

Natural Resources Defense Council (1996) Flying off Course. Environmental Impacts of America's Airports, NRDC, Washington DC, USA

Oxford Economic Forecasting (1999) "The Contribution of the Aviation Industry to the UK Economy" report for the Airport Operators' Association, the British Air Transport Association and DETR

Parsons, D. (1984) Employment stimulation and the local labour market: a case study of airport growth Regional Studies 18(5), 423-28

Pease, J (1999) Aircraft emissions head skywards. Air Quality Management, December 1999, 8-9

RCEP (1994) Transport and the Environment, Royal Commission on Environmental Pollution, 18th Report

SACTRA (1999) "Transport and the Economy" report for DETR

Shenfield, M. (1995) Employment Impact: Proof of Evidence LAH/2010 Public Inquiry into Terminal 5

T&E (1998) Sustainable Aviation. The need for a European environmental aviation charge, European Federation for Transport and the Environment, Brussels

Twomey, J. and Tomkins, J. (1995) "Development effects at airports: a case study of Manchester Airport" pp 187-211 in D. Bannister, Transport and Urban Development, E&FN Spon, London

UNEP (1999) Global Environmental Outlook 2000, United nations Environment programme, Earthscan, London

van de Pol, Y. (1998) The Myths of Flying Friends of the Earth, Amsterdam

Whitelegg, J, Hulten, S and Flink T (1993) High Speed Trains. Fast tracks to the future, Leading Edge Press, Hawes

World Health Organisation (1993) Community Noise. Environmental Health Criteria Document, WHO

World Transport Policy and Practice (1996) Special Issue "The information society and sustainable development", volume 2, Numbers 1 and 2, ecologic@gn.apc.org

Appendix

Appendix 1 Interview Script

1. Does Aviation Burning contribute to global pollution?
   - YES
   - NO

2. Do you think Aviation and Environment go hand in hand?
   - YES
   - NO

3. Has your airport been impacted by more adverse weather events, patterns, and conditions?
   - YES
   - NO

4. Do you expect impact from more adverse weather events, patterns, and conditions on your airport's infrastructure or operation in the coming 10 years?
   - YES
   - NO

5. Has your airport or another local/national government conducted a climate change-related risk or vulnerability assessment?
   - YES
   - NO

6. Do you think your country contributes or works enough towards the Environment, formulates policies to keep the organisations in check on their carbon footprint, encourages private NGOs to work effectively?
   - YES
   - NO

7. In your daily work activities at the Airport both on the Airside and Landside how much are you affected by the Noise of the Engines? Rate at a scale of 1 to 10 with '1' being the least amount of effect and '10' being the most unbearable.
   ANS - ______________________________

8. What do you think can be the new advancements in Air Travel that can make it more fuel efficient and eco-friendly at the same time? share any new technology you have heard or read about.
   ANS - ______________________________

9. Do you think there can ever be a replacement to Aviation Turbine Fuel?
   - YES
   - NO
   - and if yes what will it be? ______________________________

10. Names few of the travel options that are eco-friendly and efficient compared to air travel?
ANS - ____

11. If ever given the chance to govern the regulating authority India, what one change can you bring to the current scenario of Aviation in India?
ANS - ____

Appendix 2 List Acronyms

AAI – Airport Authority of India
DGCA - Directorate General of Civil Aviation
FAA – Federal Aviation Administration
NASA - The National Aeronautics and Space Administration
PARTNER - the Partnership for Air Transportation Noise and Emissions Reduction
ICAO - International Civil Aviation Organization
CORSIA - Carbon Offsetting and Reduction Scheme for International Aviation
IPCC - Intergovernmental Panel on Climate Change
UNEP - United Nations Environment Programme
WMO - World Meteorological Organisation
RPK - Revenue Passenger Kilometres
WHO - World Health Organisation
CO_2 - Carbon Dioxide
NO_2 – Nitrogen Dioxide
NO_X - Nitrogen Oxides
O_2 – Oxygen
PG - Propylene Glycol
EG – Ethylene Glycol
LOUT - Lower Operational Use Temperature
PGI - Propylene Glycol Industrial Grade
GAV - Ground Access Vehicles
GSE - Ground Support Equipment
AEU - Aviation Environmental Unit
ATM - Air Traffic Management
CSMIA - Chhatrapati Shivaji Mumbai International Airport
NSCI - National Safety Council of India
ATF - Airline Turbine Fuel
NGO – Non-Governmental Organization
MOEF - Ministry of Environment and Forests
CPCB - Central Pollution Control Board
SPCB - State Pollution Control Boards
GHG – Greenhouse Gas
MOCA - Ministry of Civil Aviation
MoEF&CC - Ministry of Environment Forest & Climate change
MoP&NG - Ministry of Petroleum & Natural Gas
ANS - Air Navigation Services
TERI - The Energy & Resources Institute
WWF – World Wide Fund for Nature
ATAG - Air Transportation Action Group
UNEP - United Nations Environment Programme
UHC - Unburned Hydrocarbons
PM - Particulate Matter

HAPS - Hazardous Air Pollutants
ISRO - Government of India
RCEP - Royal Commission on Environmental Protection.
ACARE - Advisory Council for Aeronautics Research in Europe
PARTNER - Partnership for Air Transportation Noise and Emissions Reduction
AEAP - Atmospheric Effects of Aviation Program
FICON - Federal Interagency Committee on Noise