Carbon Footprint of Indian Aviation 2013

Directorate General of Civil Aviation
India

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EXECUTIVE SUMMARY

Aviation industry, though a small contributor, is aggressively working to minimize the adverse impact environment. India's aviation industry has also taken proactive initiatives to address this issue. Directorate General of Civil Aviation (DGCA) has issued various guidelines for its stakeholders in order to address the environmental issues especially, one related to emissions from aircraft. Indian aviation industry has a fleet of modern aircraft with four main airports participating in the prestigious global initiative 'Airport Carbon Accreditation'. Apart from this, Airports Authority of India is also working on several projects to improve the air traffic management at airports.

In order to have sustainable aviation, following measures have been taken as proactive initiatives: stakeholders

Emissions Source	CO_2 Emissions (000 tons)			2012-2013 Change
	2011	2012	2013	
Indian scheduled passenger airlines to/from domestic destinations	6,755	6,135	6,365	**3.75%** ↑
Indian scheduled passenger airlines to/from international destinations	5,949	5,425	5,585	**2.95%** ↑
Foreign scheduled airlines to international destinations	3,623	3,829	3,680	**-3.89%** ↓
Total	**16,327**	**15,389**	**15,630**	**1.57%** ↑
Indian scheduled passenger airlines & foreign scheduled airlines to international destinations	6,597	6,542	6,472	**-1.07%** ↓
	Kgs CO_2/RTK*			
	2011	**2012**	**2013**	
Indian scheduled passenger airlines to/from all destinations	1.06	0.99	0.96	**-3.03%** ↓

**RTK: Revenue Tonne Kilometers*

have been advised to establish Environment Cell in their organizations and to develop their carbon footprint. Airlines have been advised for retrofitting on existing aircraft, adopting aggressive fuel efficiency methods, exploring the possibility of using biofuels, fixing of winglets & riblets, minimizing dead weights on board, improving load factors, adhering to the maintenance schedules, selection of appropriate aircraft on a particular route, improving taxing and parking procedures, etc.

The challenge brought by the legacy of greenhouse gases forces us to reflect upon the interests of future generations. From intergenerational equity point of view, it is our moral responsibility to maintain and sustain the environment of the Earth and an obligation to pass it on to the future generations in reasonable condition. The Precautionary Principle to contain emission at source has been ingrained in environmental laws of India and is being applied very well in Civil Aviation sector.

A carbon footprint represents an important policy tool to understand the sources and magnitude of CO_2 emissions, identify areas for intervention, make comparisons, formulate emission reduction proposals, and assess progress. In 2012 the DGCA completed, the first-ever detailed carbon footprint of Indian aviation for the year 2011. It was widely distributed in the press and was presented at ICAO, obtaining significant recognition from the international aviation community.

Given India's commitment to environmental improvements, this report maps the CO_2 emissions of Indian aviation for 2013 in a comprehensive manner and compares

them with previous data. Overall, the following estimations have been made:

a) The total emissions of 15,630,000 tons of CO_2 in 2013 represent less than 1% of India's anthropogenic emissions; which is significantly lower than the corresponding global average, which is on the order of 2%-3%.

b) In the absence of reduction measures, CO_2 emissions may reach 28,000,000 tons by 2020.

c) Although CO_2 emissions (in kgs) per RTK for Indian airlines in 2013 (i.e. 0.96) remains above the 2011 global average of 0.95, it shows a declining trend. Some Indian airlines are below the global average, while others are above, suggesting there is room for further improvements in efficiency.

d) In 2013, Indian airports emitted around 780,000 tons of CO_2.

Overall, in 2013, CO_2 emissions from Indian related aircraft operations marginally increased. This trend is related to the general passenger developments for 2013, introduction of new routes by domestic airlines and an overall increase in aircraft movements by the airlines.

In this context, development of annual carbon footprints, dissemination of information and reporting, and delivery of relevant workshops, will underscore India's commitment to addressing the challenge of aviation and climate change in a comprehensive and effective manner and safeguard the industry's potential to grow.

INTRODUCTION

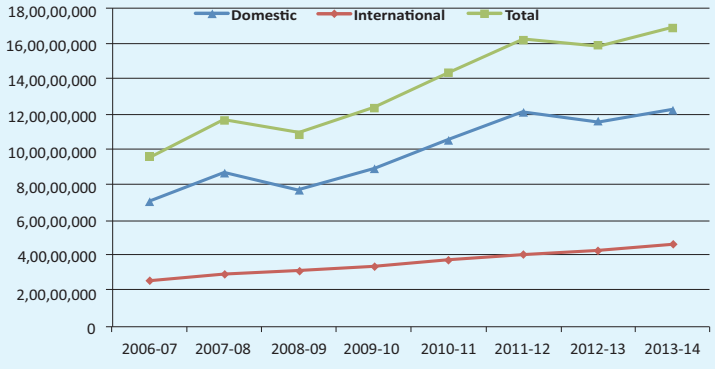
A carbon footprint is historically defined as "the total sets of greenhouse gas (GHG) emissions caused by an organization, event, product or person (Source: Wikipedia). A Carbon Footprint is an important tool for assessment of an organization's GHG emissions and its progress in the subsequent years. It also acts as an important framework tool to understand the various sources of CO_2 emissions, gap analysis and formulation of policies for emission reduction. In order to formulate an effective policy to address the challenge of climate change, it is important to identify emission trends and make predictions about its future growth. This is especially important for fast growing industries, such as Indian aviation industry.

The first carbon footprint report for the year 2011 was released by Director General of Civil Aviation and the Secretary General of the International Civil Aviation Organisation (ICAO) during the 49th DGCA Conference held in October, 2012 in New Delhi. The carbon footprint for the year 2012 was released during 38th ICAO General Assembly held at Montreal, Canada during September/ October, 2013. As a part of continuous environmental initiatives of the Directorate General of Civil Aviation (DGCA), this report maps the carbon footprint of Indian aviation for the year 2013 in a comprehensive manner while comparing with previous data.

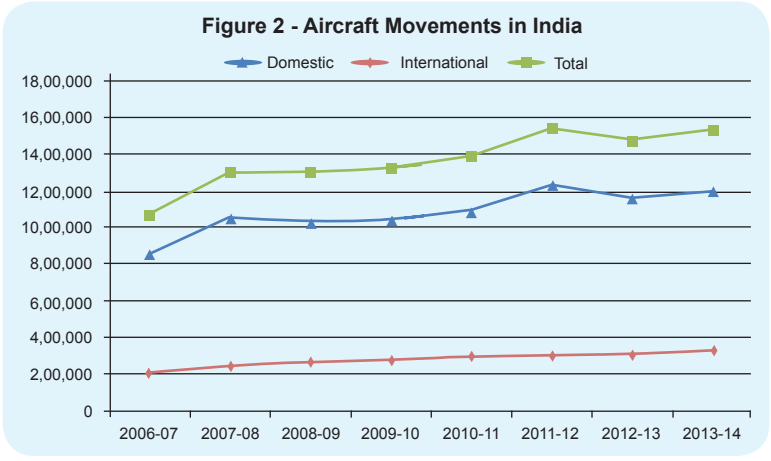
India represents a growing aviation market with more than 100 airports that during fiscal year 2013/2014

handled around 170 million passengers (Figures 1 and 2). The major scheduled passenger airlines operate more than 400 aircraft. Aviation represents around 1.5% of India's GDP and supports 9 million jobs, while the country ranks 9th in the global civil aviation market. It is expected that domestic and international passenger traffic will continue to grow at rates of 12% and 8% respectively and that India will become the 3rd largest aviation market in the world by 2020.

Figure 1-Passenger Evolution in India



India's aviation industry significantly contributes to the development of the country, but inevitably also leads to environmental challenges, especially regarding climate change. In order to formulate an effective policy to address the challenge of climate change, an important requirement is to determine the sources and level of aviation's CO_2 emissions, identify trends and make predictions about future growth. This is especially important for fast growing industries, such as Indian aviation.



At the same time, the country's aviation stakeholders have taken a number of important steps to address their contribution to climate change. DGCA has issued numerous guidelines addressing emission issues and is delivering regular environmental training sessions, Indian airlines operate modern aircraft fleets, four airports are participating in the prestigious Airport Carbon Accreditation program, while several initiatives are contributing to improved traffic management also.

INDIAN CLIMATE CHANGE INITIATIVES

India has been active in addressing the climate change challenge. India ratified the Kyoto Protocol, has been involved in the international negotiations to develop a successor to this protocol, formulated a National Action Plan on Climate Change (2008), introduced eight National Missions (e.g. enhanced energy efficiency, strategic knowledge for climate change), established the Indian Network for Climate Change Assessment, and developed several Clean Development Mechanism projects.

Regarding aviation and climate change, in a breakthrough development in late 2013, the International Civil Aviation Organisation (ICAO) agreed to develop a global market based system for aviation emissions in its next Assembly meeting scheduled in 2016 for implementation from 2020 and to establish a CO_2 emissions standard. Although the exact nature and implications to airlines of this system are not currently known, it is likely that it will be based on some form of carbon offsetting creating incentives for emissions reduction.

Until recently, Indian scheduled airlines flying to European Union (EU) countries, were supposed to be part of the EUs Emissions Trading Scheme (ETS). Over the years, India took a leadership role in opposing with many other countries (e.g., US, Russia, China) the EU-ETS, refusing to provide data to the EU and supporting the work of ICAO. The ICAO agreement practically put an end to EU's initiative to include foreign airlines in their ETS. This was further corroborated by EU's decision in 2014 to restrict the ETS only to intra-European flights.

Within this framework, a number of initiatives are also being implemented in the Indian aviation sector.

Government Initiatives

DGCA issued many guidelines addressing the use of aircraft power supply, fuel efficiency, single engine taxi and data reporting. One of the most important initiatives is Aviation Environment Circular 2 of 2013 on Climate Change Initiatives in Civil Aviation. According to this circular, the airlines and airports shall submit fuel and electricity consumption data on a regular basis and develop their own carbon footprint. DGCA also undertook the first-ever detailed carbon footprint of Indian aviation for 2011. Furthermore, a number of training sessions and workshops on climate change have been delivered to industry representatives both in India and abroad.

Airline Initiatives

Indian airlines play an important role regarding emissions reductions. They operate modern, fuel-efficient aircraft (e.g. Boeing 787 Dreamliner, Airbus 320/B737 NG with sharklets/winglets) resulting in significant fuel savings. At the same time, they have been changing the mode of operations to reduce their emissions as well. Table 1 presents some indicative airline initiatives.

Table 1 Indicative Emissions Reduction Initiatives by Indian Airlines	
AIR INDIA	Use of Pratt & Whitney's EcoPower engine wash to clean the aircraft engine fuel path and the turbine blades to improve aerodynamic characteristics is expected to reduce fuel consumption on an average by 1.2%. [1]
BLUE DART	Blue Dart uses single engine taxi procedures and has provided awareness sessions and training for planning and executing constant descent profiles.
IndiGo FLY SMART go	IndiGo and Go Air have opted for the installation of sharklets on new aircraft, which can increase fuel efficiency by 3-4%.
JET AIRWAYS	Jet Airways has established a program to continuously monitor and reduce the weight of various catering, cabin and galley items, which has contributed to fuel savings. It has also developed an Integrated Emissions Management System (IEMS) for monitoring and optimization of aviation fuel usage.
spicejet	Fuel management improvements regarding extra fuel carried on flights have led to an estimated 0.5% emissions reduction per flight. Additional benefits are realized through systematic implementation of single engine taxi procedures during arrivals.

[1] *ICAO, Guidance Material for the Development of States' Action Plans, p. 87 (September 2011) and Air India, Green Initiatives for Air India.*

Airport Initiatives

As of 2013, several Indian airports have obtained LEED certifications (Leadership in Energy and Environment Design), use energy efficient systems, operate environmentally friendly vehicles, etc. Further, four Indian airports are participating in Airport Carbon Accreditation (Table 2).

Table 2
Airport Carbon Accreditation in India

Airport Carbon Accreditation was developed and launched by Airports Council International (ACI)-Europe in 2009. It is the only institutionally endorsed carbon management certification standard for airports. The programme consists of four different levels of accreditation:

1) **Mapping**	Development and verification of a carbon footprint
2) **Reduction**	Establishment of carbon management plan & emission reduction target
3) **Optimisation**	Engagement of Third Parties in emission reductions
4) **Neutrality**	Offsetting of the airport operator's emissions[2]

As of mid-2014, Airport Carbon Accreditation's membership includes more than 80 European airports accounting for over half of Europe's passenger traffic, such as London, Paris, Frankfurt, Madrid, Amsterdam, Rome, Athens, Zurich, Milan, Brussels and Manchester. Ten airports have been accredited as carbon neutral. This initiative extended to airport operators in the Asia-Pacific (15 participants) and Africa (1 participant) regions in 2011 and 2013 respectively.

As of mid-2014, **Bangalore, Hyderabad,** and **New Delhi** airports have been accredited at the Optimization level and **Mumbai** airport at the Reduction level. These airports have established carbon footprints and have taken additional measures, such as adoption of green design principles and energy efficiency initiatives. The table below shows the number of airports at each level, suggesting the significant achievement of the Indian airports, which participate at a high accreditation level.

[2] *Scope 1 and 2 emissions.*

Participation in Airport Carbon Accreditation				
	Mapping	Reduction	Optimization	Neutrality
Airports	36	23	20	16

Air Navigation Services Initiatives

India has launched the Future India Air Navigation System (FIANS) initiative, which is based on projects in the fields of communication, navigation and surveillance. Indicative projects include implementation of Performance Based Navigation (PBN), use of Automatic Dependent Surveillance-Broadcast (ADS-B), harmonization with international systems, human resources development and training, etc. A PBN roadmap has been developed and several projects have already been launched. For example, PBN implementation at some airports has already reduced flight distance.[3] In 2011, the Indian Ocean Strategic Partnership to Reduce Emissions (INSPIRE) was launched. This project represents a partnership between the Airports Authority of India (AAI), Airservices Australia, Dubai Airports, airlines, and many other organizations, which are "dedicated to improve the efficiency and sustainability of aviation." Relevant initiatives include the development of operational procedures, technologies and best practices, establishment of performance indicators, development of systematic processes, and communication initiatives. A number of test flights have been conducted, while the project partners have established recommended procedures, practices and services that are environmentally beneficial.[4]

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[3] *MOCA, India: The Emerging Aviation Hub (2012).*

[4] *Information from http://www.inspire-green.com, accessed on 22/3/2013.*

Biofuel Initiatives

Biofuels have been identified as one of the major vehicles for reducing CO_2 emissions. Biofuels have additional advantages, such as the possibility of local production from a number of different feedstocks (e.g., jatropha), as well as reduction of fuel price volatility and reliance on fossil fuels.

Starting with Virgin Atlantic in early 2008, more than 20 test flights have been flown to date. In 2011, seven different carriers performed commercial flights using up to 50% biofuel. While the safety and feasibility of this fuel type has been demonstrated, what remains is building up capacity and becoming cost competitive with aviation turbine fuel (ATF). For biofuels to become a viable alternative, they need to capture a minimum of 1% of the aviation fuel market.[5] IATA has estimated that if by 2020 a 6% mix of biofuels is used, CO_2 emissions could be reduced by 5%. IATA has set a target of 10% blending by 2017.

In India, there have been some encouraging developments regarding biofuels and aviation based on cooperation between Indian companies, public institutions, and foreign entities (e.g. Indian Oil Corporation, Airbus, Indian Institute of Technology, Pratt & Whitney Canada, McGill University). These efforts have focused on design and research issues mainly regarding camelina and jatropha. For example, the Hydroprocessing Lab of the Indian Institute of Petroleum has developed aviation jet fuel from jatropha for engine testing that meets international specifications, while a pilot plant is in operation that can produce 20 liters/day. Both Jet Airways and Air India have plans to use biofuel on a domestic demonstration flight.

[5]*Air Transport Action Group (ATAG), Beginner's Guide to Aviation Biofuels, Edition 2, (2011).*

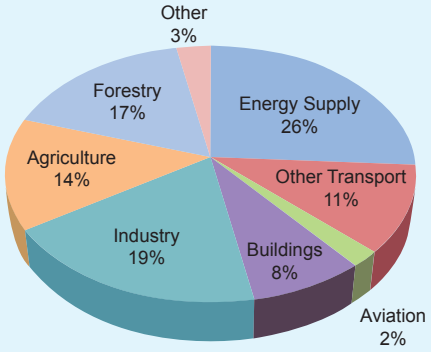
However, significant challenges remain, such as lack of technology adoption and feedstock supplies, while in order to promote the use of biofuels in aviation an innovative and cooperative framework is required among all stakeholders.

In conclusion, India and its aviation industry have taken a number of important steps to address aviation's contribution to climate change.

GLOBAL AVIATION CARBON FOOTPRINTS

In 2013, global passenger airline operations emitted approximately 705 million tons of CO_2, representing around 2%-3% of global anthropogenic CO_2 emissions (Figure 1). Within the industry, aircraft emissions represent approximately 95% of emissions, while the remaining 5% are related to airport activities.[6]

Figure 1 - Distribution of Global CO_2 Emissions



The most comprehensive information on emissions from domestic and international (i.e. bunker fuel emissions) scheduled passenger flights was published in 2013 by D. Southgate, providing detailed data on a per country, airline, and airport basis.[7] The methodology is based on analysis of datasets of aircraft operations, average fuel consumption, distance and emissions calculations, etc. According to

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[6] *Information from ATAG, Aviation Benefits Beyond Borders, April 2014, p. 6, and http://www.atag.org/facts-and-figures.html, accessed on 26/5/2013. Also, IPCC Fourth Assessment Report, WG III, Technical Summary (2007); ACI-Europe & WSP, Airport Carbon Accreditation Annual Report 2010-2011, (2011); D. Southgate, Global Scheduled International Passenger Flights – 2012, (2013), p. 46..*

[7] *D. Southgate, Aviation Carbon Footprint-Global Scheduled International Passenger Flights – 2012, (2013) and D. Southgate, Aviation Carbon Footprint-Global Scheduled Domestic Passenger Flights – 2012, (2013).*

Southgate, global emissions from aviation bunker fuels in 2012 ranged between 360-470,000,000 tonnes of CO_2.[8] Emissions from international flights in the Asia-Pacific region were responsible for 106,000,000 tonnes of CO_2.

Table 3 shows the estimated 2012 domestic and international aviation CO_2 emissions of a number of countries. The USA is by far the main CO_2 emitter, followed by China (with a very significant domestic sector) and the UK (with a very significant international sector).

With respect to the situation in India, in 2013 emissions of Indian scheduled passenger airline operations to/from domestic destinations were estimated at 6,365,000 tonnes of CO_2. The CO_2 emissions related to bunker fuels from Indian and foreign airlines to international destinations from India reached 6,472,000 tonnes.

Table 3
2012 Aviation CO_2 Emissions of Selected Countries (in 000 tonnes)

Country / Operation	USA	China	UK	Germany	Australia	Brazil	India	Thailand	S. Korea	Indonesia
Domestic	96.956	36.806	1.487	1.796	7.044	9.796	6.135	1.464	1.247	5.637
International	47.871	13.899	24.654	18.729	9.489	5.929	6.542	8.207	8.305	3.064
Total	**144.827**	**50.705**	**26.141**	**20.525**	**16.533**	**15.725**	**12.677**	**9.671**	**9.552**	**8.701**

Source: D. Southgate, Aviation Carbon Footprint-Global Scheduled Domestic Passenger Flights – 2012, (2013) excluding data for India.

[8] *D. Southgate compares the study's results with ICAO, International Energy Agency (IEA), and ATAG data.*

CARBON FOOTPRINT METHODOLOGY

Stakeholders

The development of the carbon footprint of the Indian aviation sector requires the contribution from various entities regarding policy developments, data collection, reviews, development of databases and other initiatives. The following stakeholders were mainly involved with these tasks (Figure 2):

***Directorate General of Civil Aviation (DGCA)*:** Nodal point for issuing the relevant guidelines, communicating requests to airlines and airports, collecting/presenting data, and undertaking analysis.

***EU-India Civil Aviation Cooperation Project (ICCA)*:** Provision of resources, advice, and analysis to produce the carbon footprint.

***Airlines/Airports*:** Submission of information and data regarding their operations.

***Others*:** Provision of additional information regarding fuel consumption, emission levels, etc. by organizations, such as the Ministry of Environment and Forests (MOEF), the Ministry of Petroleum and Natural Gas (MOPNG), and the International Energy Agency, etc.

Data Collection

The methodology for the development of the carbon footprint follows the Tier 1 approach of the Intergovernmental Panel on Climate Change (i.e. aggregate Aviation Turbine Fuel (ATF) quantities from airlines and other sources).

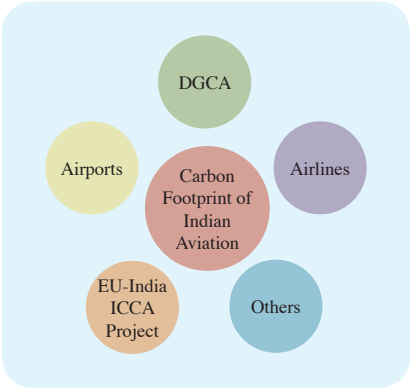


Figure 2: Main Stakeholders of the Carbon Footprint of Indian Aviation

Information from Indian airlines and airports is based on the form contained in the DGCA's Circular 2 of 2013 on Climate Change Initiatives in Civil Aviation. This form focuses on ATF from scheduled airlines as well as electricity and fuel consumption from operations (e.g. vehicles, generators) of large airports (i.e. airports having more than 50,000 annual aircraft movements). Information on ATF uplift of foreign airlines was based on information provided by MOPNG aggregate statistics.

In 2013, the Indian aviation industry consisted of seven scheduled passenger airlines, which were responsible for the transportation of more than 61,400,000 domestic passengers. This report has been developed using data provided by the six scheduled passenger airlines and the four joint venture airports (Table 3). Air Costa started its operations in late 2013 and hence was not considered in this report owing to their small emissions that is negligible in comparison to the overall emissions of the other scheduled airlines.

Table 3 Main Data Sources	
Scheduled Passenger Airlines	***Joint Venture Airports***
Air India Group*	Bangalore
Jet Airways	Delhi
JetLite	Hyderabad
Indigo	Mumbai
Spicejet	
GoAir	
*Includes Air India, Air India Express & Alliance Air.	

Calculation & Reliability

This section describes how CO_2 emissions were calculated for each emission source as well as the level of data reliability.

***Aviation Turbine Fuel (ATF)*:** For airlines, ATF is in most cases initially reported in the aircraft technical logs and then transferred to a corporate database. Various departments, such as Finance, Quality Control, and Engineering undertake comparisons and quality control checks (e.g. through fuel invoices). On some occasions external verifiers or other institutions (e.g. IATA) certify that the methodology used for data collection is in accordance with international guidelines. Given that fuel has historically been one of the most significant cost and operational inputs for airlines, there is a reliable system of tracking consumption overtime. Therefore, reliability of ATF data is considered high.

The MOPNG (Petroleum Planning & Analysis Cell) provided ATF uplift information in India broken down into categories, such as foreign airlines, Indian airlines, and other consumption.[9] As this refers to aggregate statistics, there is some level of data uncertainty.

***Electricity*:** The joint venture airports implement adequate data collection and verification processes, given the clear boundaries of operation and availability of electricity invoices. Electricity consumption data for the whole airport as well as consumption by the airport operating company only were collected. As a result, it was also possible to estimate the aggregate electricity consumed by third parties (e.g. airlines, ground handlers, etc.) operating at the airport. The reliability of electricity data is considered high.

***Other Fuels*:** In the case of petrol, diesel, CNG and LPG, which are mainly used for vehicles, generators, etc., the data sources are mainly related to invoices from refuelling stations. Where possible, quality control is undertaken (e.g. Finance Department through invoices). Potential sources of error may be related to mistakes in data entry, incorrect charging of fuel type, omissions, etc. In general, the joint venture airports have a well-developed system for data collection and analysis, which in some cases is also verified by external institutions (e.g. Bureau Veritas).

Table 4 presents the various fuel types, the emission factors, and the relevant references. Where necessary, airports and airlines provided additional data and clarifications on data collection procedures, validity, calculations, etc. Furthermore, regarding quality control it was possible to

[9] *"Other" refers to general aviation, resellers, etc.*

Table 4 Emissions Factors Information		
Fuel Type	**Emission Factor**	**Reference**
ATF	3.157 tonnes of CO_2/tonne	ICAO (2011), Guidance Material for the Development of State Action Plans, p. 19
Petrol	3.14 tonnes of CO_2/tonne	DEFRA: 2011 GHG Conversion Factor Repository
Diesel	3.16 tonnes of CO_2/tonne	
CNG	2.70 tonnes of CO_2/tonne	
LPG	1.49 tonnes of CO_2/m3	
Electricity NEWNE*	0.82 tonnes of CO_2/MWh	Ministry of Power (2014), Central Electricity Authority, CO_2 Baseline Database for the Indian Power Sector, Table S-1
Electricity South*	0.85 tonnes of CO_2/MWh	
** Two emission factors are available depending on the location of service provision (NEWNE: Integrated North Eastern Western & North-Western regional grids and South: Southern Grid).*		

compare the carbon footprint data and indicators of this study with data from different sources (e.g. MOPNG), alternative indicators (e.g. emissions per passenger), 2011 carbon footprint data, as well as other studies that have addressed Indian emissions. All data have been entered in a database.

Overall, the data collection and analysis process allows for a reliable analysis of the carbon footprint of Indian aviation.

CARBON FOOTPRINT FOR 2013

This section provides detailed information regarding theThis section provides detailed information regarding the carbon footprint of Indian scheduled passenger airlines for 2013 and makes comparisons with 2012 and 2011 data. Figure 3 delineates the breakdown of CO_2 emissions.

The emissions of Indian scheduled passenger airlines to/from domestic destinations for 2013 was 6,365,000 tons of CO_2, a 3.75% increase compared to the 6,135,000 tons of CO_2 emitted in 2012 and a 5.78% reduction compared to 6,755,000 tons of CO_2 emitted in 2011.

The emissions of Indian scheduled passenger airlines to/from international destinations for 2013 was 5,585,000 tons of CO_2, a 2.95% increase compared to the 5,425,000 tons of CO_2 emitted in 2012 and an 6.11% reduction compared to the 5,949,000 tons of CO_2 emitted in 2011.

In total, the carbon footprint of Indian scheduled passenger airlines to/from domestic and international destinations for 2013 was 11,950,000 tons of CO_2, a 3.37% increase compared to the 11,560,000 tons of CO_2 emitted in 2012 and a 5.93% reduction compared to the 12,704,000 tons of CO_2 emitted in 2011.

The emissions of foreign scheduled airlines to international destinations from India for 2013 was 3,680,000 tons of CO_2, a 3.91% reduction compared to 3,829,000 tons of CO_2 emitted in 2012 and a 1.57% increase compared to the 3,623,000 tons of CO_2 emitted in 2011.[10]

[10] Based on ATF uplift data from India obtained from the MOPNG. Only emissions of foreign airlines "to" international destinations are included (and not "from") in order to be consistent with International Energy Agency guidance on international bunkers and to avoid double counting. Airlines that did not uplift fuel in India are also excluded due to lack of data.

Consequently, the total emissions of Indian scheduled passenger airlines to/from domestic and international destinations as well as of foreign scheduled airlines to international destinations from India for 2013 reached 15,630,000 tons of CO_2, a 1.57% increase compared to

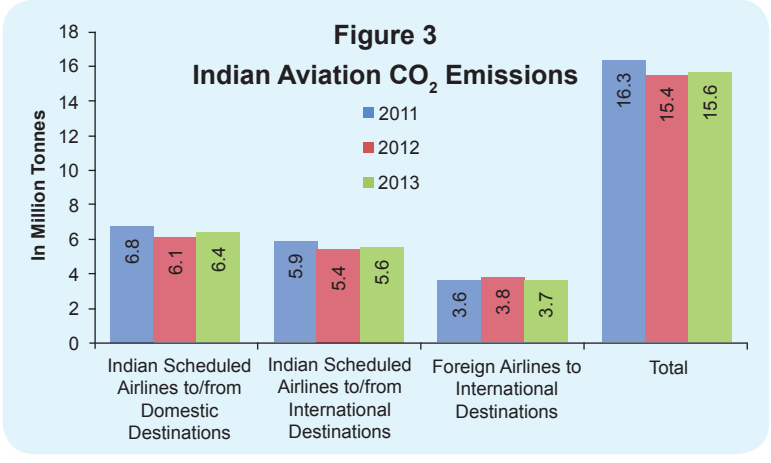


Table 5
Global vs. Indian CO_2 Aviation Emissions

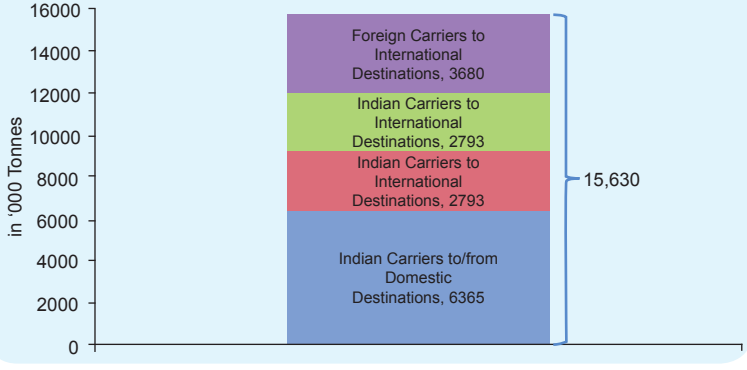
In 2013, global airline operations were responsible for the emission of 705,000,000 tons of CO_2, representing approximately 2%-3% of global anthropogenic emissions. In comparison, emissions of Indian scheduled airline operations to/from domestic/international destinations as well as of foreign airlines to international destinations (i.e. 15,630,000 tons of CO_2) represented less than 1% of India's anthropogenic emissions.[11]

[11] *Latest data available for India refer to 2011, when 1.97 billion tons of CO_2 were emitted (PBL Netherlands Environmental Assessment Agency & European Commission, Trends in Global CO_2 Emissions, (The Hague, Netherlands, 2012).*

15,389,000 tons of CO_2 emitted in 2012 and a 4.27% decline compared to the 16,327,000 tons of CO_2 emitted in 2011. Overall, the increase of Indian airlines emissions and of foreign airlines emissions follows the general passenger trends for 2013.

In accordance with international standards, international aviation bunkers (i.e. emissions from fuel use for international civil aviation) should be reported separately. Emissions of Indian scheduled passenger airlines as well as foreign scheduled airlines to international destinations from India for 2013 reached 6,472,000 tons of CO_2, a marginal decline of 1% compared to the 6,542,000 tons of CO_2 emitted in 2012 and a 1.89% decline to the 6,597,000 tons of CO_2 emitted in 2011.[12] Figure 4 depicts the 2012 CO_2 emissions by destination and airline.

Figure 4
2103 CO_2 Emissions by Destination and Airlines

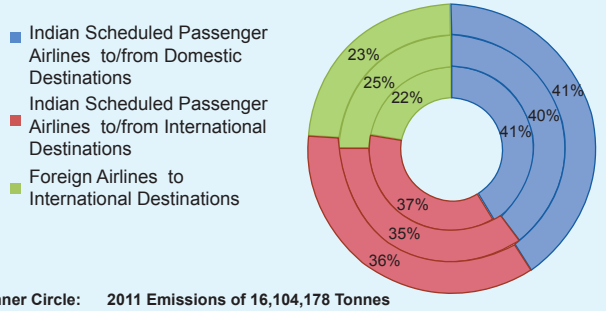


[12] *Intergovernmental Panel on Climate Change, Guidelines for National Greenhouse Gas Inventories, Understanding the Common Reporting Framework, (1996).According to ICAO, Guidance Material for the Development of States' Action Plans, (2011), p. 17, international are flights with one or both terminals in the territory of a country, other than the country in which the air carriers has its principal places of business. Domestic flights are those not classifiable as international. The contribution of Indian airlines to international destinations is calculated as half of their total contribution to/from international destinations.*

For validation purposes, the emissions from international flights from India and for domestic flights were compared with the outcomes of the Aviation Carbon Footprint-Global Scheduled International Passenger Flights and Global Scheduled Domestic Flights studies for 2012. The estimates from these studies differ by 9.8% and 2.2% respectively compared to the emissions estimated in this section. Given the different methodologies used, this outcome provides further evidence about the validity of the results presented here.

Figure 5 compares the 2011, 2012 and 2013 CO_2 emissions by destination and airline on a percentage basis, suggesting that there have been relatively small changes. This increase is attributed to their increased activity in 2012 compared to the Indian airlines.

Figure 5
2011-2012-2013 CO_2 Emissions by Destination & Airline



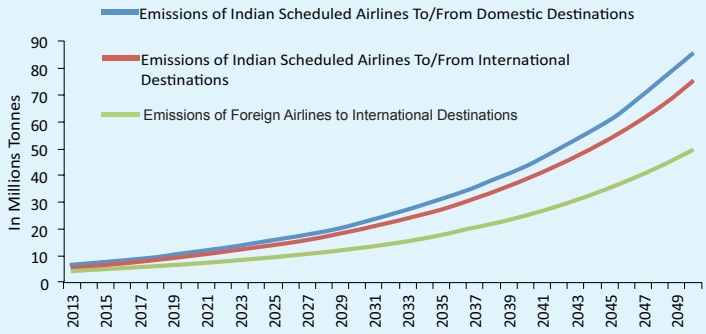
Inner Circle: 2011 Emissions of 16,104,178 Tonnes
Middle Circle: 2012 Emissions of 15,389,000 Tonnes
Outer Circle: 2013 Emissions of 15,630,000 Tonnes

It is also important to predict the long-term evolution of CO_2 emissions. This task incorporates some inherent difficulties since predictions for the growing and changing

Indian market are difficult to make. However, such a forecast can set the baseline for Indian aviation's future emissions in the absence of any reduction measures. The MOPNG predicts an annual growth rate of ATF fuel consumption of 9% (2013-2016) and 8% (2017-2020).[13] For the period 2021-2050, this report uses a 7% growth rate.

Figure 6 suggests that the baseline emissions of Indian scheduled passenger airlines from domestic and international operations in 2020 are estimated at approximately 11,000,000 and 10,000,000 CO_2 tons respectively. Emissions of foreign scheduled airlines to international destinations emissions are estimated at 6,500,000 tons.

Figure 6
Projected Growth in CO_2 Emissions

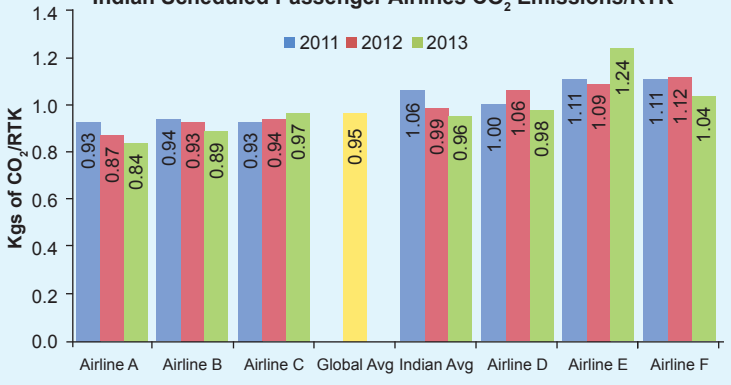


The internationally accepted efficiency indicator for carbon emissions is kgs of CO2 per RTK. The average for Indian airlines in 2013 was estimated at 0.96 compared to 0.99 in 2012, an improvement of 3.7% over the previous year (Figure 7). Although this number remains above the 2011 global average of 0.95, the comparison with 2011

[13] *Information from the MOPNG, Petroleum Planning & Analysis Cell, at http://ppac.org.in.See Forecast and Analysis, Demand Projection XII and XIII Plan.*

and 2012 shows a declining trend. Some airlines show a significant reduction (i.e. Jet Airways), small reduction (i.e. SpiceJet, GoAir, Air India group) or small increase (i.e. IndiGo, JetLite). Some Indian scheduled passenger airlines

Figure 7
Indian Scheduled Passenger Airlines CO_2 Emissions/RTK



are still above the global average, suggesting there is room for further improvement in efficiency.[14]

The trends presented in the previous paragraphs can be attributed to the general passenger developments for 2013, the improved efficiency of some Indian airlines, due to higher load factors and use of newer, more fuel-efficient aircraft (e.g. Spicejet's Q400). At the same time the efficiency level of airlines that have started new sectors in remote areas with lower load factors, is expected to be lower.

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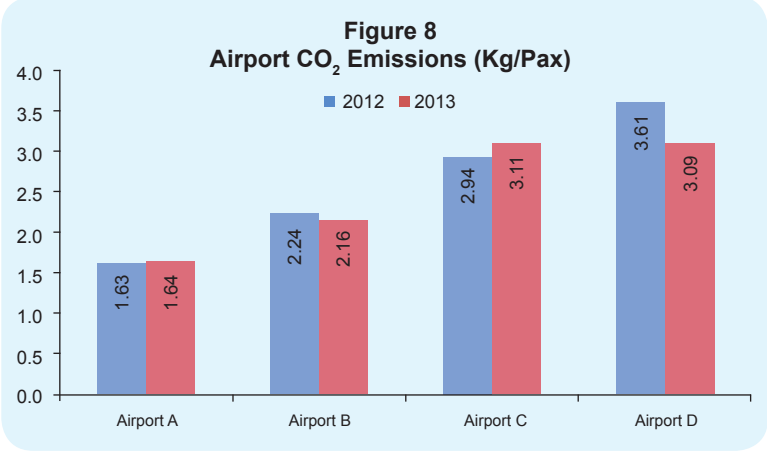
[14] P. Steele, Air Transport Action Group, Aviation & Environment, Presentation at the 68th IATA AGM Meeting (Beijing, China, June 2012). Calculations based on the 2011 average global fuel consumption of 37.49 litres/100 RTK. According to D. Southgate, The Carbon Footprint of Aircraft Operations in Australia – 2011, (October 2012) the 2011 average of Australian aviation is 0.96 kgs/RTK. According to S. Korea's presentation at ICAO's Symposium on Aviation & Climate Change (14-16 May 2013) regarding the Action Plan to Reduce GHG Emissions from International Aviation in 2010 the country's fuel efficiency of international aviation was 0.99 kgs/RTK. The globalCO2/RTK for 2012 is not yet available. The 2011 data for GoAir have been updated based on more recent calculations.

As discussed earlier, approximately 95%-98% of aviation's emissions are emitted from aircraft while the remaining originate from airport related activities. Applying this assumption (i.e. 5%) to the 15,630,000 tons of CO_2, it is estimated that Indian airports emitted around 780,000 tons of CO_2. This number is consistent with data provided by four joint venture airports, which was then extrapolated for all Indian airports.

Figure 8 presents the CO_2 emissions (in kgs per passenger) for the four joint venture airports. These emissions are related to sources that are owned or controlled by these airports as well to electricity consumption for their operations (excluding third parties). Electricity consumption is the main source of airport emissions. Consequently, differences between airports are not only relevant to variations in efficiencies, but also to infrastructure characteristics (e.g. size of buildings, area, number of runways, etc.).

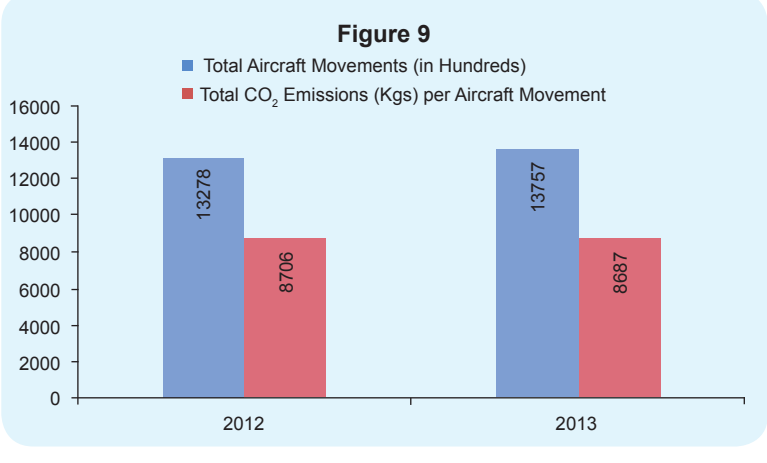


It is important to mention here that although the airports have shown a significant reduction in energy consumption over the previous years, the increase in the emission factors by Ministry of Power for electricity consumption in 2013 has reduced the overall efficiency of the airports. MIAL had a marginal decline of 1% in emission (Kgs of CO_2/Passenger), BIAL had improvement of 4%, HIAL had a decline of 17% and DIAL had an improvement of 9% over the previous year respectively.

Although airports make a small contribution to CO_2 emissions compared to aircraft operations, they represent a focal point for climate change interventions to improve airline operations, such as taxi times, power provision, etc.

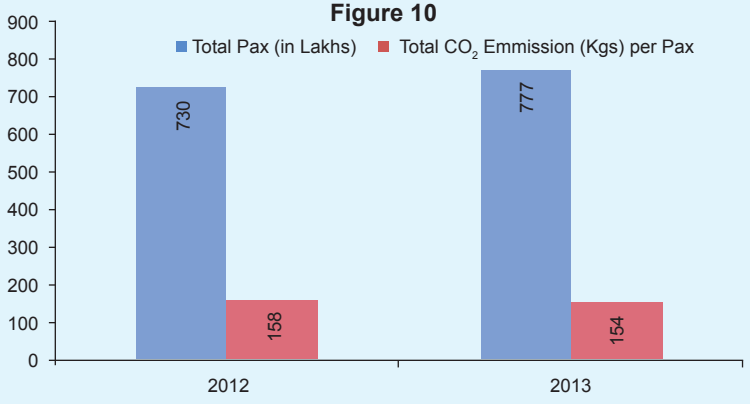
Growth vs Emissions – A Comparison:

It has been observed that in 2013, although overall aircraft movements increased by 3.61% over 2012 (from 13,27,772 to 13,75,715), decrease in the carbon emission per aircraft movement by 0.22% (from 8706 kgs to 8687kgs) has been registered during the same period (Figure 9).



It has been also observed that in 2013, the passenger growth has witnessed an overall growth of 6.42% over 2012 (from 7,30,10,774 to 7,77,01,549), however, the carbon emission per passenger has decreased by 2.86% (from 158.3 kgs to 153.8 kgs) during the same period (Figure 10).

Figure 10



PROPOSALS

Given the significant expected growth of Indian aviation, inevitably CO_2 emissions are likely to increase. In order to minimise the rate of increase and maximise the effectiveness of climate change policies, the following actions are required to be taken, several of which are already included in the Aviation Environment Circular 2 of 2013 on Climate Change Initiatives in Civil Aviation.

***Development of Annual Carbon Footprint*:** It is important to continue with the development of annual carbon footprints to establish trends, monitor progress, and identify areas of potential intervention. The annual update is especially important given the evolving nature of the Indian aviation industry (e.g. high growth, new entrants), which influences the level of emissions. Aviation Environment Circular 2 of 2013 provides for the development of annual carbon footprints both at the national level as well as at the airport and airline levels.

***Dissemination of Information*:** The carbon footprints should also be publicised both within the Indian aviation industry (e.g. airlines, airports, DGCA website), internationally (e.g. ICAO, IATA, ACI), as well as with the general and specialised aviation press, in order to showcase the meaningful efforts of India regarding aviation and climate change.

***Delivery of Workshops*:** Regular workshops should continue to be provided to Indian airlines and airport operators in order to promote increased awareness concerning aviation's role in climate change, improve data collection procedures, identify areas for efficiency interventions and encourage collaboration amongst aviation's stakeholders.

***Reporting*:** Airports and airlines should provide information on voluntary measures taken to reduce CO_2 emissions, effects, timeline, expected results, especially in relation to fuel efficiency, reduction of emissions from airport functions and ground operations, etc. Also, stakeholders shall also submit to DGCA the relevant reports if their organizations have been certified in accordance to ISO standards (e.g. ISO-14001, ISO 14064) or are participating in Airport Carbon Accreditation or a similar initiative.

***International Climate Change Initiatives*:** In 2013, the 38th ICAO Assembly agreed on Resolution 17/2, "Consolidated statement of continuing ICAO policies and practices related to environmental protection – Climate change." ICAO shall develop global market based measures for international aviation emissions to be approved at the next Assembly in 2016 and implemented from 2020. It should be ensured that specific conditions of India (like growth of aviation market, level of development) are taken into consideration in order to meet both its developmental and environmental protection aspirations.

***Airport Infrastructure*:** Since airports represent a nodal point of aviation activities, such as airline flights, passenger/public access, and third party operations (e.g., ground handling, catering, fuelling), they can and must play a central role in emission reductions as pressure concerning the climate change issue increases. Airports can also contribute to the reduction of aircraft emissions through more efficient use and planning of airport infrastructure. Close cooperation between airports, airlines, and the public authorities is always necessary to achieve improvements in this field.

***Airline Operations*:** For airlines, emphasis should be given to operational efficiency through improved flight planning, aircraft weight reduction, single-engine taxi procedures, minimal use of Auxiliary Power Units, etc. which can lead to emissions reductions and cost savings. Airlines can also participate in carbon offsetting initiatives, such as IATA's relevant program and collaborate with other aviation stakeholders on promoting the adoption of biofuels.

***Air Navigation Services*:** Air Navigation Services (ANS) efficiency improvements represent an important opportunity for CO_2 emissions reduction, but also for increased capacity and improved safety. For e.g. in Australia, new ATM procedures for the Sydney-Melbourne route are expected to reduce CO_2 emissions by 40,000 tonnes per year.

CONCLUSIONS

The process of developing the carbon footprint of the Indian aviation sector for 2013 has provided a very good understanding of the sources of CO_2 emissions, the availability and reliability of data from airlines and airports, emission trends, as well as required future initiatives.

Within this context, the development of annual carbon footprints, dissemination of information and reporting, and delivery of relevant workshops, will underscore India's commitment to addressing the challenge of aviation and climate change in a comprehensive and effective manner and safeguard the industry's potential to grow.