

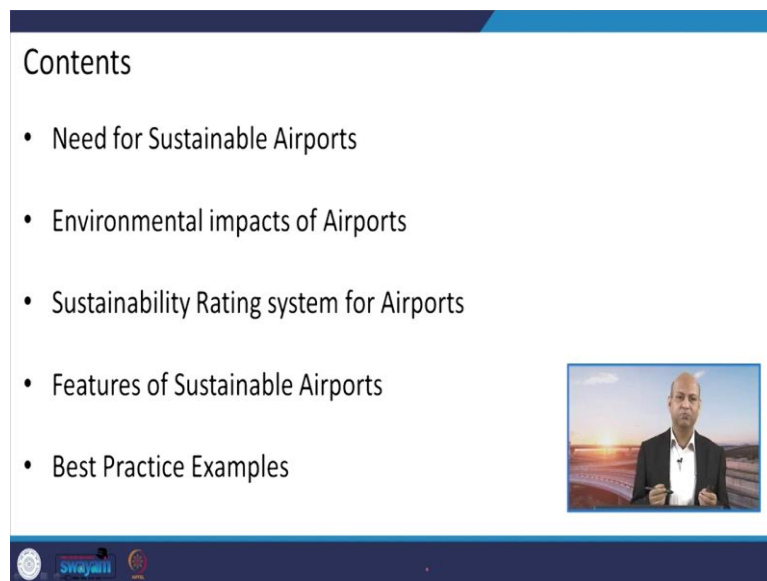
**Sustainable Transport System**  
**Professor Bhola Ram Gurjar**  
**Department of Civil Engineering**  
**Indian Institute of Technology, Roorkee**  
**Lecture 52**

**Case Study-III: Sustainability in Airports**

Hello friends, so in the series of case studies regarding sustainable transportation systems, today we will discuss about sustainability aspects of airports, we have already discussed BRTS, Bus Rapid Transits System and then MRTS, Mass Rapid Transits System and this is airport, which is also again mass transit system in a sense, because millions of passengers are using these days airports for travelling from one city to another city within the country or in different countries.

So, this is the contents list of this lecture like, what is the need of sustainable airports, because any kind of transportation system we want them to be sustainable, because of their different kinds of impacts, if impacts are very harmful, if they are beyond certain limits, then they are not sustainable, so we have to look on those issues.

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Contents

- Need for Sustainable Airports
- Environmental impacts of Airports
- Sustainability Rating system for Airports
- Features of Sustainable Airports
- Best Practice Examples

The slide includes a small video inset of a man in a suit speaking, and a footer with logos for IIT Roorkee and Swajani.

And environmental impacts of every kind of transportation system we have been discussing, so for airports also we will discuss what are environmental impacts and in what way different airports are addressing those issues. So, in the parallel of environmental impacts, we will also see how sustainability is measured for different airports like, different rating systems or ranking systems are there for sustainability attributes and what are the features of sustainable airports, how do we define whether this is sustainable or not and then the best practices

examples we will look into of different airports which are most sustainable in comparison to other airports.

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The slide is titled "Need for Sustainable Airports" and contains the following content:

- Airports play a **vital role in local and National economies**.
- Can create **significant environmental impacts**.
- Some of the environmental impacts from airports includes **air, water and noise emissions, land use and energy consumption**.
- **Balancing the benefits** of potential growth from airports **and minimizing the negative environmental impacts** is a challenge and can be achieved through sustainability.

Visual elements on the slide include:

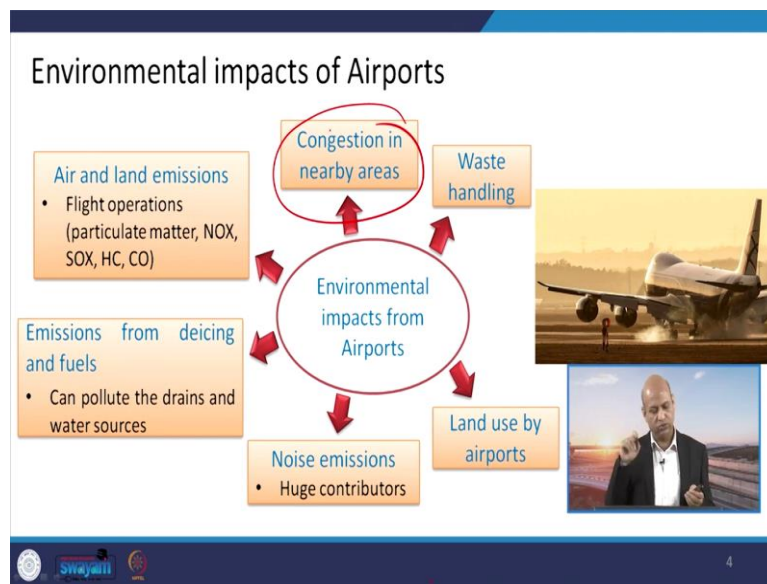
- An orange oval image of an airplane on a runway.
- A green box with the text: "Over **2500** airports worldwide and **4 billion** annual passengers".
- A small video inset showing a man in a suit speaking.
- Logos for "Swayam" and "MOE" at the bottom left.
- The number "3" at the bottom right.

So, why the need of sustainable airports very simple reason because, they are the vital local or national economic engines you can say, because a lot of goods is transported through airports and passengers are also using these airports for travelling across the world then, they can create significant environmental impacts because huge amount of fuel is burned for, providing energy to all these aircrafts.

Then there are certain environmental impacts which are common of any kind of transportation system like air, water or noise emissions and then land use, land planning, energy consumptions, so over the 2500 airports worldwide and around 4 billion annual passengers are using these airports in total, so the huge impact can be there on all components of the environment. So, we have to see the impact of these airports on the environmental attributes.

Then what are the benefits means off course, they contribute in the economy as goods are transported, passengers are transported, so lot of constructive role is there in economics. But also at the same time there are like risk in terms of their negative impacts, so we have to see what are the balance is between kind of risk benefit analysis or against analysis you can say.

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If we want to see the environmental impacts in totality, so like congestion in nearby areas, because if feeder system is not good, if approaching roads are not good, then when at the peak hours when people are travelling towards airports or they are going from the airport to their destination, so in nearby areas, there may be congestion and again the condition results into lot of fuel burning, emissions and the duration of air quality and of course, economic loss, because of fuel burning.

Then waste handling, because wherever human activities are there at a particular centre in a concentrated way, so a lot of waste will also be generated, there will be so many facilities for restaurants or these rest rooms, etc. So, whether it is liquid waste or solid waste, there will be several waste streams, so we have to handle those waste streams in a proper way.

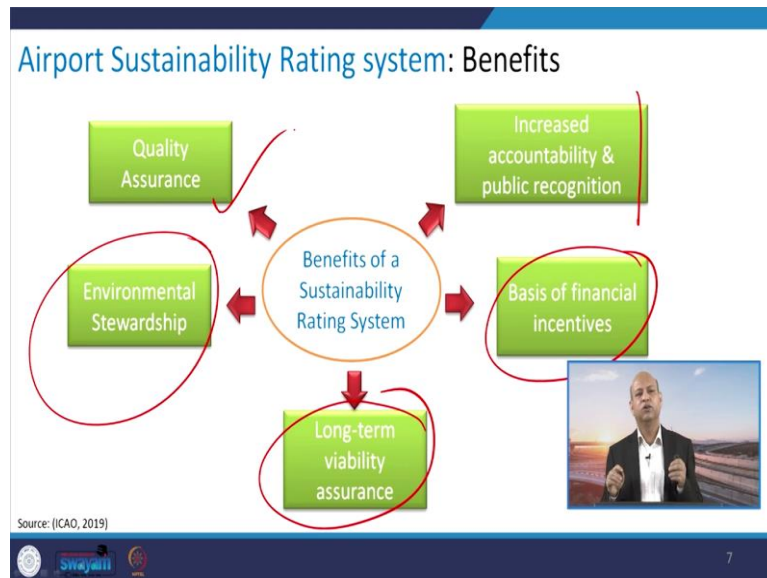
Land used by airports huge land is required because, several kilometres for air traffic, parking as well as runways and then, there are godowns or warehouses and then hangars for the airports, so many facilities and these arrivals or departure joints and all those dimensions are there for complete airport station.

Noise emissions, so because jet engines create a lot of noise, so again as I think in one particular lecture, we discussed that sometimes because of noise properties near to airports do not pick up in prices and people do not like to live in nearby areas, because there is a lot of disturbance in daily life. Then emissions from like fuels or deicing activities in cold countries and so deicing activities can pollute drains and also water sources and then air and land



Then, there are several rating systems for seeing whether it is sustainable or not and there are two most popular and oldest kind of time-tested ranking systems or rating systems and these are one is LEED, that is Leadership in Energy and Environmental Design and another one is BREEAM, that is Building Research Establishment Environment Assessment Method, so these are the two very popular rating system, so that we will discuss in detail.

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Then there are the benefits of rating system, why do we go for rating system, because they give us an idea, some sort of idea whether a good rating system is there then we can, visualise that that particular airport should be good in terms of handling waste and reducing environmental impacts etc. So, what are those different aspects or dimensions in terms of benefits like increased accountability and public recognition, because better rating perception is good people will see in a very good eyes that, this airport is managed very nicely.

Then basis of financial incentives because, if airports are providing good services, they have good rating, more people will feel incentive to use those airports, if there are not good enough facilities then people will refrain to use it continuously, they may go for another alternative transportation system or alternative airports. Then long-term viability assurance, because if that particular airport is continuously getting good rating, so the long-term viability in terms of investment, in terms of viability of financial incentives etc, would be there.

Environmental stewardship that means, it will give you an idea that environment is taken care of properly, quality assurance is also there, that overall quality means of the services of other kind of related activities, the quality is assured in terms of good rating.

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**Sustainability Rating system for Airports**

**LEED (Leadership in Energy and Environmental Design)**

- **Most widely recognized** Green building certification system in the world.
- **Developed by the US Green Building Council**, and provides a framework for healthy, efficient, cost-effective green building design, construction, operation and maintenance practice.
- **Key areas of evaluation** includes:
  - Location and transport
  - Energy and Atmosphere
  - Sustainable sites
  - Materials and Resources
  - Water efficiency
  - Indoor Environmental Quality

Source: (ICAO, 2019)

Well, when we see this particular LEED rating system, so it is of course, most widely recognised green building certification system in the world, so many countries in many organisations, institutions establishments are using this particular system and this is developed by US Green Building Council another one is from Europe, we will see in the next slide and they provides a an overall framework.

Like, if it is healthy environment, if it is efficient or it is cost effective green building design is there or not. construction activities have been taken care of, in terms of better facilities for labourers, as well as less emissions in the construction activities and then operation and maintenance practices are good or bad means it is quickly provided or not then complaints are addressed very quickly and effectively or not.

Then, there are some key areas of evaluation in this system like, location and transport, energy and atmosphere, material flows, resources, water efficiency and what is the site sustainability is there or not and the indoor environmental qualities parameter also discussed and used for this and how it is represented?



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### Sustainability Rating system for Airports

#### LEED Certification (4-tier Certification)

- LEED Platinum
- LEED Gold ✓
- LEED Silver ✓
- LEED certified

Source: (ICAO, 2019)

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It is represented in a very nice manner or attention catching error manner like, if points are like 40 to 49 points in that checklist, so it is called as LEED certified, if points are more like 50 to 59 then, it is a LEED silver certification and the next one is for 60 to 79 that is the gold and the platinum is 80 plus points, so these kind of four tier certification rating system is there in the lead.

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### Sustainability Rating system for Airports

#### BREEAM (Building Research Establishment Environmental Assessment Method)

- Introduced by the UK Building Research Establishment (BRE) in 1990.
- Widely used Certification system in Europe, having 10 categories and 71 criteria.
- Key areas of evaluation includes:
  - Management
  - Health & well-being
  - Energy
  - Transport
  - Water
  - Materials
  - Waste
  - Landuse & Ecology
  - Pollution
  - Innovation

Source: (ICAO, 2019)

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Well the another parallel system which was produced by UK building research establish that is the BREEAM this is also used quite widely and particularly European countries they use it

frequently and it is in 10 categories and 71 criteria it includes so it is quite comprehensive you can say.

Well the key areas here for evaluation are management and the materials health and the well being waste several common are there in the lead and this BREEAM weighting system energy transport water pollution or innovation is a good parameter here means, continuous improvement is there or not and then the land use and ecology the last step.

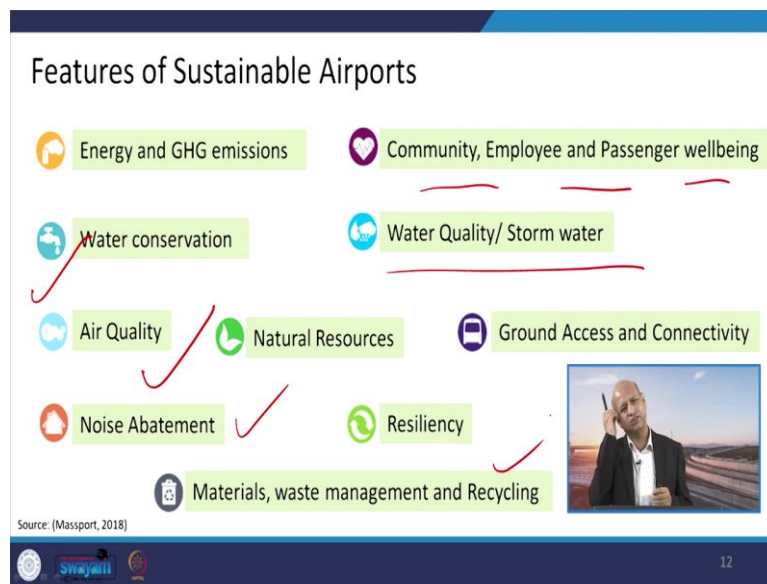
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The slide is titled "Sustainability Rating system for Airports" and "BREEAM Certification (Star Rating from 1 to 5)". It features two sample BREEAM certificates on the left. The first certificate is for "Greenwich Warehouse" and the second is for "BREEAM New Construction 2014 Industrial". To the right of the certificates is a diagram of a star rating scale from 1 to 5. The 1-star level is labeled "Pass" and is circled in red. The 5-star level is labeled "Outstanding level". A green arrow points upwards from the 1-star level towards the 5-star level. Below the star scale is a small video inset showing a man in a suit. At the bottom left of the slide, it says "Source: (ICAO, 2019)". At the bottom right, there is a logo for "swajathi" and the number "11".

And this is the way this is the example that stars will be there, so one can easily see whether it is 5 star or 4 star or 3 star 2 star and 1 stars just pass, so 1 to 5 star rating or levels are there in this BREEAM certification system



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Then, we come to those features those important aspects of sustainability in terms of the airports, so what are those like energy and GHG emissions means, we will judge according to the energy consumption, if lot of energy intensive activities are there, then the airport may be kind of not so good.

Similarly, greenhouse gas emissions if it is much more then again it is not a good sign, but if some measures are being taken by the airport authorities and that greenhouse gas emissions are being reduced energy consumption is being reduced over the period of time, then we can say that this airport is moving towards sustainable growth,

Then community employee passenger well being whether they are taken care of properly or not, so this is also one part of sustainability because, if working conditions are not good, then people may not feel happy there and slowly the good people whose market value is more whose employability is more, they will shift from this place to another airport and then the airport will lose the good people.

So, again this is a kind of vicious cycle and the more bad services more losing good people and that we it is a downside movement, water quality storm water handling all those facilities are there or not, then ground access and connectivity means, if there are no good feeder system or last mile connectivity is not good at the airport, then again this is a problem, because to reach to the airport or from the airport to go to railway station or bus station or to

some other mode of transport, if there is not good connectivity, then it is a problem that will really reduce its chances towards sustainability.

Natural resources, whether we are conserving natural resources, we are using them in a good manner or we are harming them, then these are the again most important aspects, water conservation, air quality, all those things, , noise abatement is there or not resiliency means, if something bad happens then again, weather quickly it adjust to the good quality standard materials, waste management, recycling, all those aspects are the features or important features of sustainability in case of airports. Now, we look into different good practices. So, from a world over, we have taken a few examples of those airports which are known for its good services and they are kind of ranked high in the air quality operations.

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So, the Boston, BOS Boston Logan International Airport in the US, this is the first airport to be LEED accredited or credited, so this system was applied here and it got very good ranking in that way and what are those aspects which helped me to get LEED certification.

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### Major Sustainability measures at BOS

- Heat reflecting roof and windows
- Self-dimming lights
- Storm water filtration
- Water efficient plumbing and irrigation
- Energy efficient electric lighting
- Construction waste recycling & Use of recycled local materials
- Adhesives, sealants, paints and carpets used have limited or no VOC's.
- Low-flow faucets and waterless urinals



Source: (Shireen Kjassim, 2014)

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Because, it has like, there are lights which are self dimming means, if people are not using that area that will dim and if some people approach then sensors will be there, they will automatically switch on the needful lights and heat reflecting roofs and windows, so that it does not capture more heat if more heat capture absorption is there then we will need more air conditioning systems, so load will be there more power consumption will be there, so if we have those kind of material which can reflect the heat, then it is an advantage, so this kind of system is there in this view as airport.

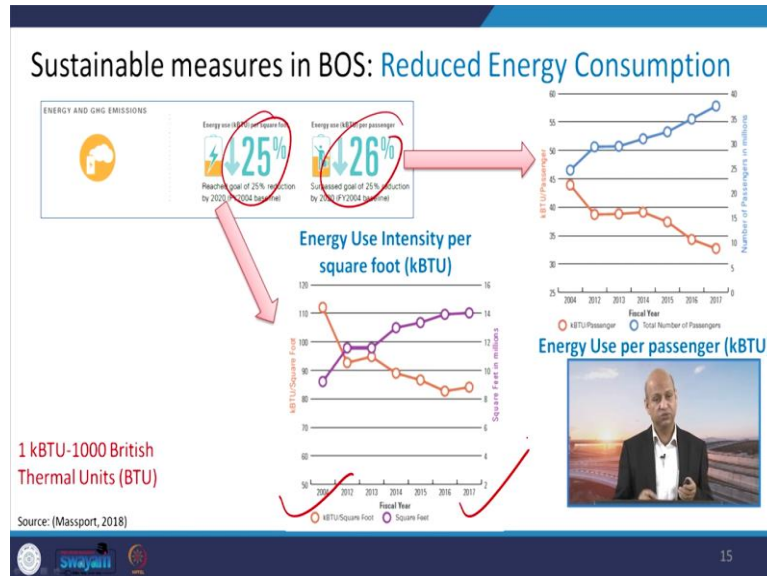
Storm water filtration, so the stone water handling heads another aspect means it is not only to put it away from the these facilities, but also filter them properly and maybe recycling or reuse then water efficient plumping an irrigation system is there, because there are facilities which need water, so those kinds of facilities they have incorporated energy efficient electric lighting at public places or walking streets, etc.

Construction waste recycling and use of recycled local material, they have been used in a big way, so this is one positive aspect of this airport then paints or those carpets and adhesives all these, they sometimes use rather most of the times these kinds of chemicals use VOC's is or the Emmet volatile organic compounds.

So, in this particular airport they have kept this they have been very careful to use those kinds of adhesives or paints with Emmet very less VOC's then low flow, waterless urinals etc.,

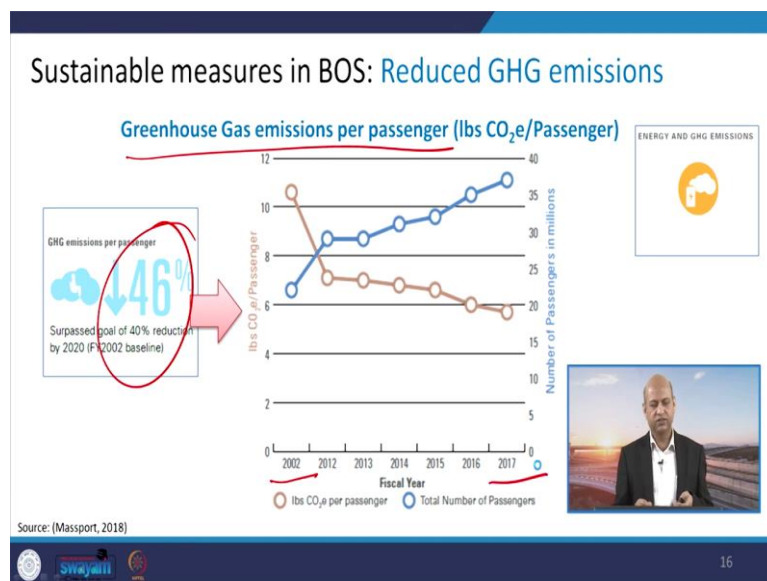
those kinds of facilities are available these days they are expensive initially, but later on, the operational cost is quite optimum.

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Here you see very interesting data like, energy use intensity per square foot of the area and energy use per passenger, so you can see this reduction is there around 25 to 26 % in between 2004 and 2017, so that means, good practices are being adopted there.

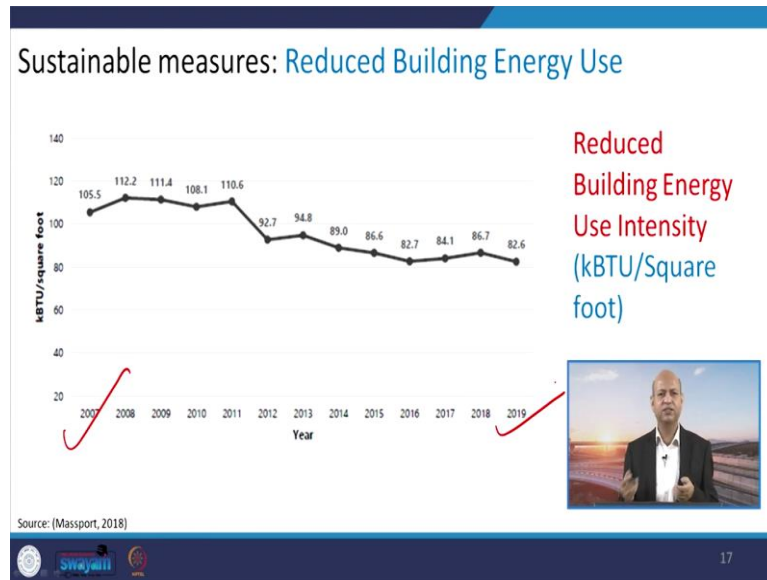
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At the same time you can see a number of passengers in millions are rising, but greenhouse gas emissions per passenger is decreasing that means, those services are there, although the

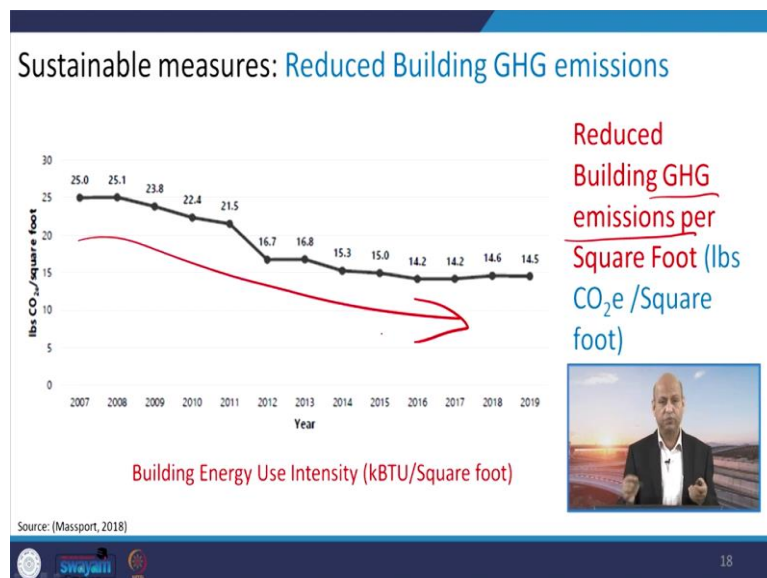
load is more and more people are using those particular facilities and services, but they have maintained in such a way that the emissions per person is reducing, so 4 to 6 % reduction is there between these 2002 to 2017.

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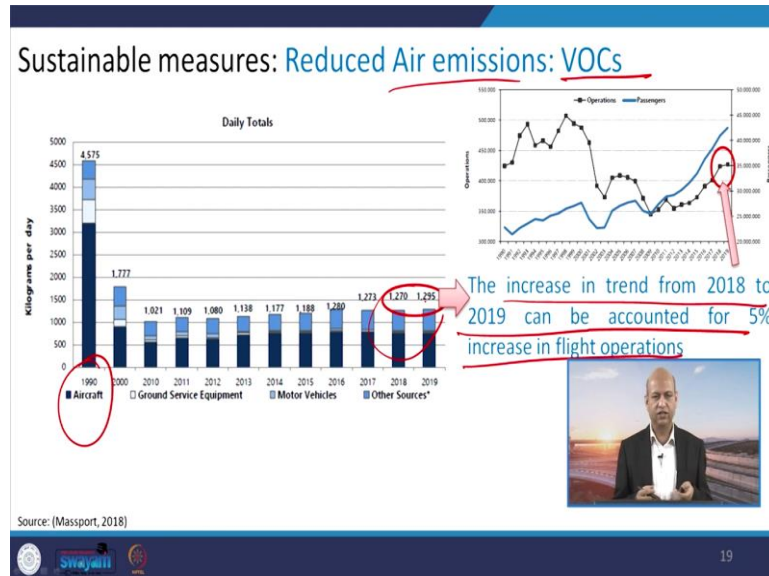
Similarly, reduced building energy use intensity is also there over the years from 2007 to 2019, so these are the indicators which shows that, they have used those kinds of technology and practices which are helping them to achieve like, less energy and better services.

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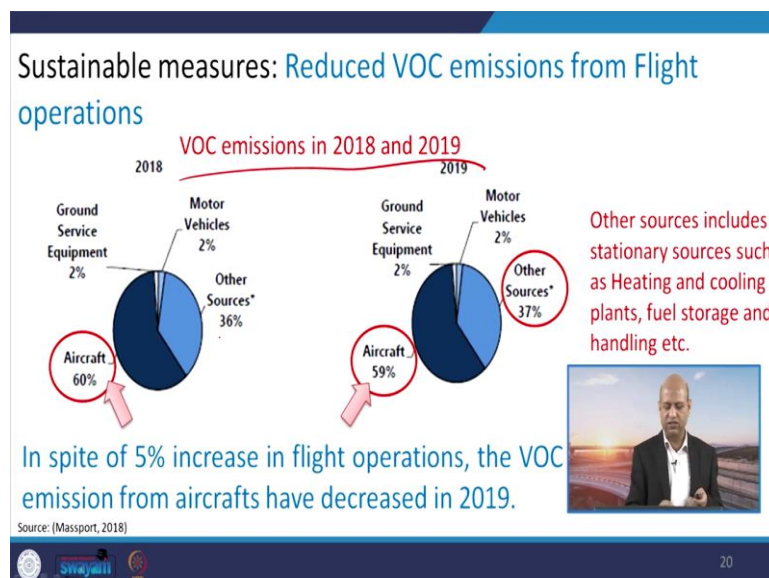
Similarly, greenhouse gases are emitted like decreasing trend over the years building from the building energy systems.

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Similarly, like air emissions of VOC's, so it was very high in 90s, but later on, they use those kinds of materials and practices and technology which emitted very less VOC's and here also you can see that this increasing trend from 2018 to 2019 can be accounted for 5 % increase in flight operations, so there is a slight increase, but because flight operations are also increasing more services are there more passengers are being handled at that airport, so that is a very nominal increase that is not a big increase or jump.

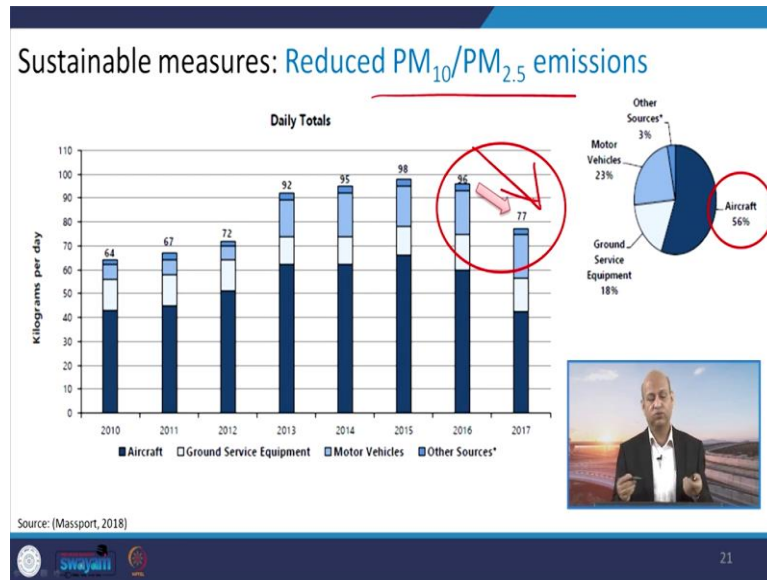
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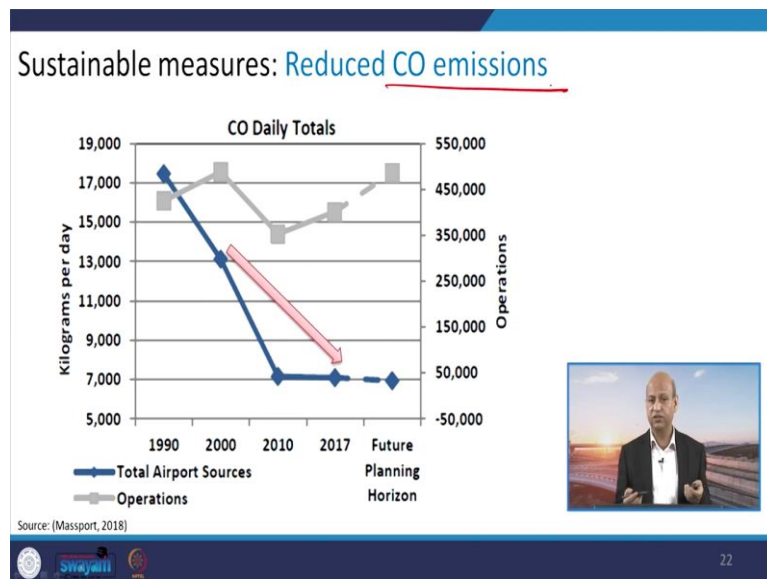
VOC emissions means volatile organic compounds emissions 2018 19 it is almost similar there is no much change only like 60 36 59 37 so, there is only the change in the sector of one, but the total is not very high change.

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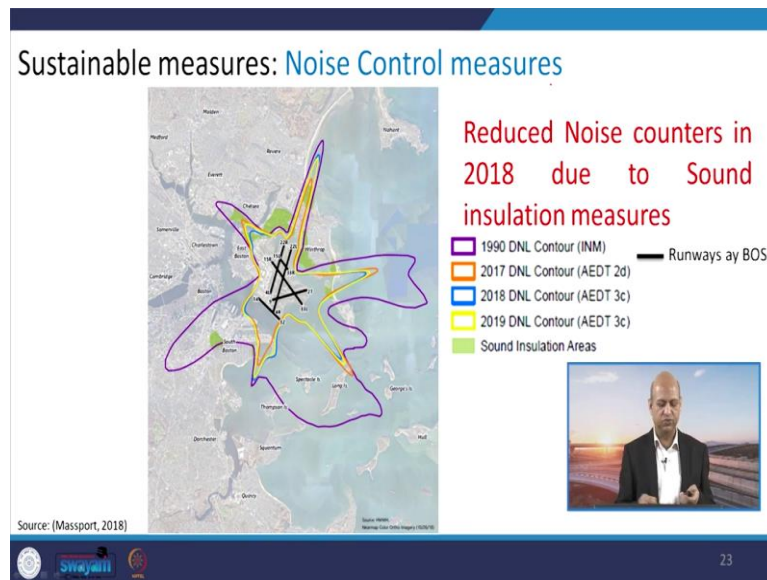
Similarly, these reduced PM10 or PM2.5 that fine particle emissions are again they are also reducing, so those kinds of good practices are there.

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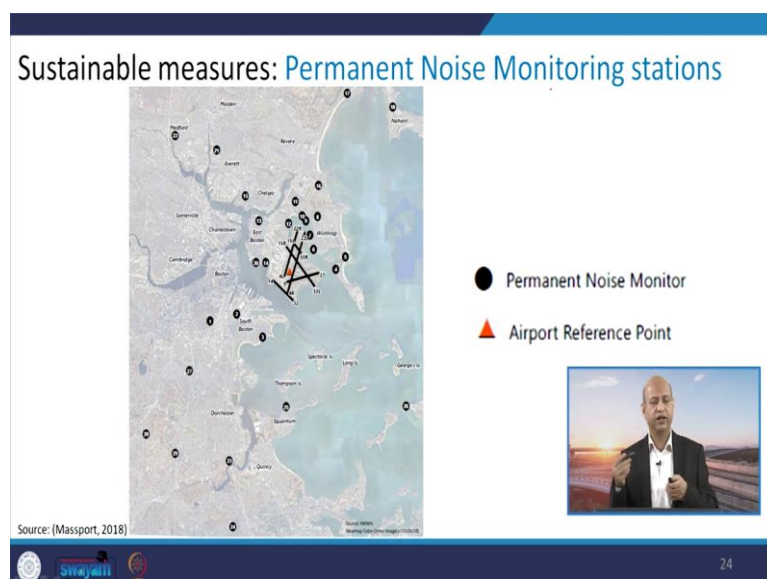
And you see this CO emissions means all weather particulates emissions or carbon monoxide emissions or greenhouse, gas emissions every kind of emission is being reduced various services of usage of passengers or the operations they are increasing, so that is a good sign.

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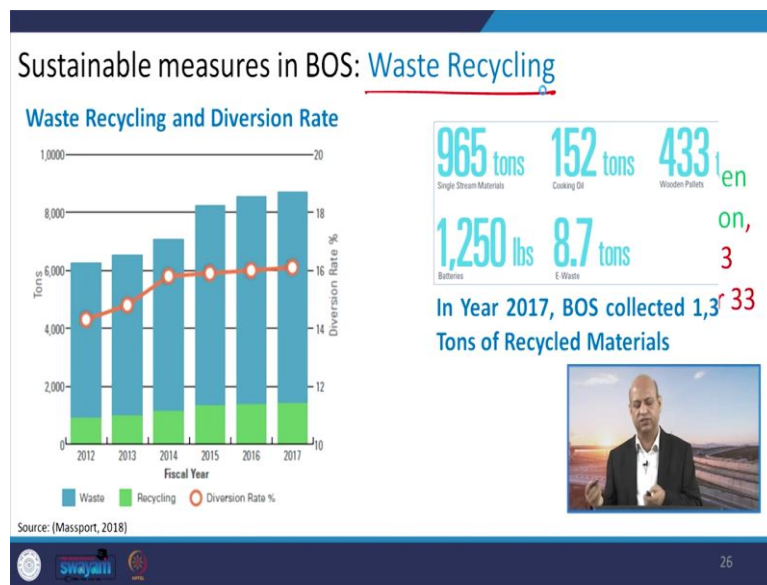
Noise control related methodologies are there and they have put in place in a nice way, so the installation system which is being shown here in a graphical way they have put in place.

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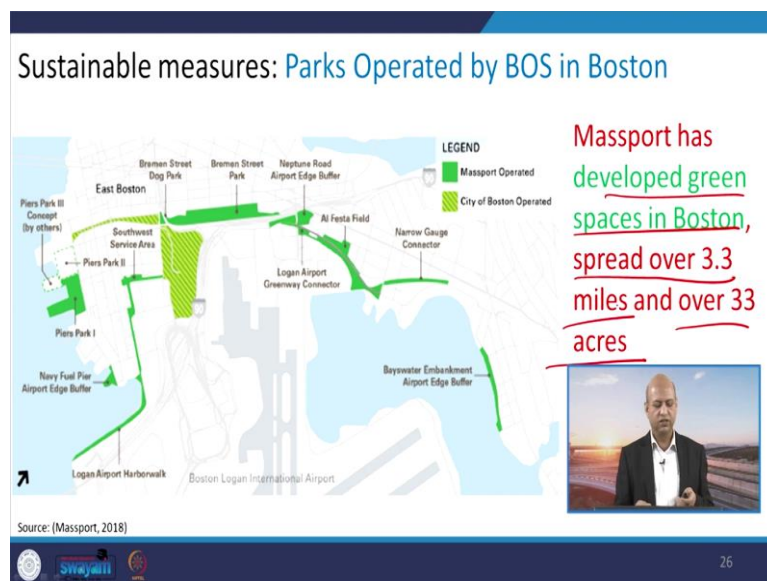
And then permanent noise monitoring stations are also there so that data can be analysed and timely some measures can be implemented at a particular location more noise is occurring.

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When we talk about waste recycling, so waste recycling is also increasing every year, so more water is being recycled every year.


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Then, if you see this green spaces in this particular airport, so that is also a spread in a quite large area, so over 33 acres spread over 3.3 miles, so this is occupied by green areas, so that is again environment friendly approach and the public transport accessibility, so it is very nicely linked with other public transportation systems, so that is why this connectivity of different modes of transport is nicely network.

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### Sustainable measures: Feeder Bus services (Express) to BOS



BOS has efficient bus accessibility to and from the airport from all parts of the Boston city.

Logan Airport

Main Roads

Massachusetts Municipalities

2018 Ridership (2019 Ridership)

Logan Express Stations

Logan Express Routes

MBTA Station

Back Bay

Braintree

Framingham

Needham

Woburn

Blue Line

Green Line

Orange Line

Red Line

Silver Line

Framingham Logan Express bus  
Source: Alan Dines

Source: (Massport, 2018)

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Similarly, these feeder buses or express buses are there to take passengers from airport to other mode of transport and for back.

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### Sustainable measures: Alternate Fuel Vehicle Fleet options

Fuel Type	Vehicle	2018	2019
Diesel/Electric Hybrid	Shuttle Bus <sup>1</sup>	32	32
Compressed Natural Gas (CNG)	CNG NABI Bus <sup>2</sup>	22	22
Gasoline/Electric Hybrid	Ford Escape	2	4
Propane	Non-Road Vehicles (Forklifts)	1	1
E85 Flex Fuel	Pick-Up Truck	18	30
	Van	2	2
	Ford Escape	2	3
Plug-in Electric Hybrid	Chevy Volt <sup>3</sup>	2	9
<b>Total</b>		<b>81</b>	<b>103</b>

Replacement of 96 diesel rental car buses and older CNG buses with a fleet of 54 alternative fuel buses (diesel-electric hybrids and newer generation CNG) for serving the new Rental Car Center

Source: Massport, 2020

1 The 32 diesel/electric hybrid shuttle buses, added to the fleet in 2013, replaced the diesel rental car buses.

2 The CNG NABI buses replaced the 26 aging CNG shuttle buses.

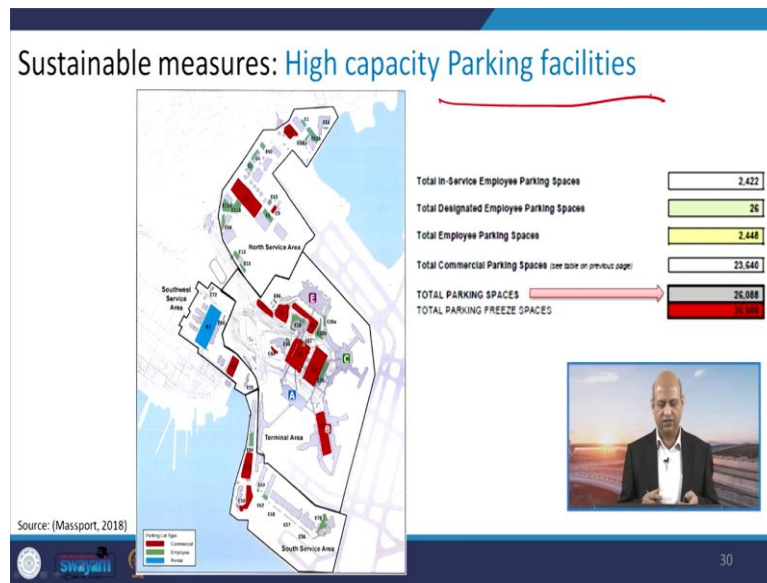
3 The Chevy Volt Plug in electric hybrid vehicles replaced the CNG Honda Civics.

Source: (Massport, 2018)

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Alternate fuel vehicle fleet operations because, when hybrid buses are there then, they are emitting less amount of greenhouse gases where pollutants, so those kinds of buses or CNG and nowadays, electric buses and electric battery operated many kind of vehicle categories are put in place in these public places.

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High capacity parking facilities are there, so that these vehicles do not move here and there they just park and they access the airport.

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Similarly, high capacity parking facilities have increased over the years, so you can see these commercial spaces employs spaces in service commercial spaces, so the increasing trend is there that means, when more passengers are accessing the more facilities are there.



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Sustainable measures: Bicycle parking facilities






Source: (Massport, 2018)

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At the same time non motorised vehicles or bicycles and those kind of healthy modes of transport they are being encouraged for the public, so the bicycle parking facilities also there, if somebody wants to park it, if they are living in nearby areas and means people come there to work and they can use bicycles also.

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Sustainable measures: Energy saving Dynamic glass at BOS



Source: (Massport, 2018)

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Then there are sustainable measures in terms of energy saving dynamic glasses, which can use energy as like sunglasses are heat reflecting and then according to the weather, they also change colours, because of some crystal Meccarin those kinds of advanced glasses are also available nowadays.



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### Zurich Airport, Switzerland



Some green initiatives includes:

- Aircraft Ground Energy Systems (AGES)
- Rain water collection
- Photovoltaic plant
- Glass façade Climate buffer
- Energy piles
- Noise management

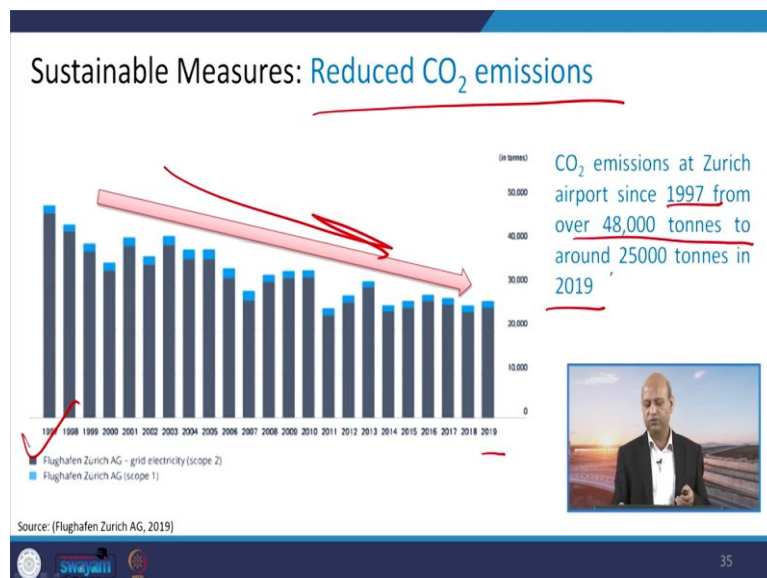


Source: (<https://www.avionews.it/resource/29668-aeroporto-di-zurigo.html>)

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When we talk about Zurich airport, so some green initiatives at the Zurich airport also includes like, glass fakers climate buffers as I said related to weather system, rainwater collection, photovoltaic plants, all those less energy or more renewable sources of energy utilisation, noise management's, all these things are there in this particular airport, that is why a lot of green initiatives are there.

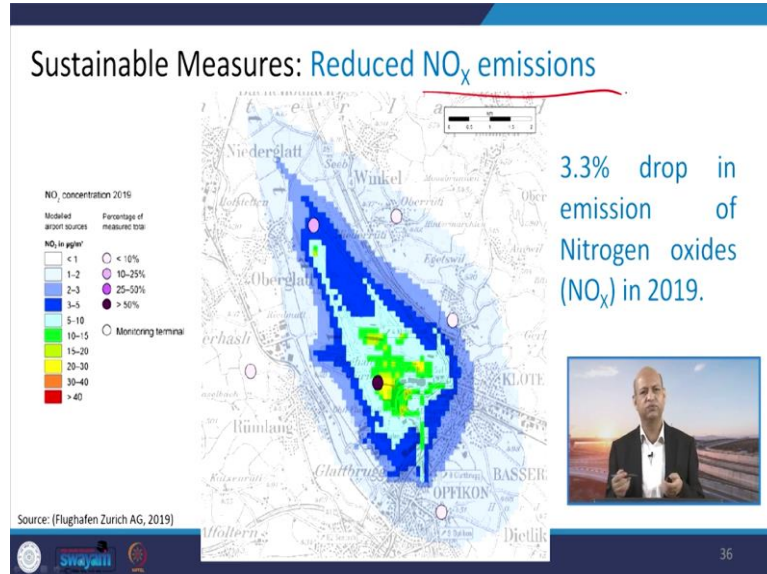
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And as a result, you can see the reduced CO<sub>2</sub> emissions, so over the years, there is a trend analysis from 97 to these 2019 you can see the overall trend is the decreasing trend, so that means they are handling properly though, the operations are increasing passengers are

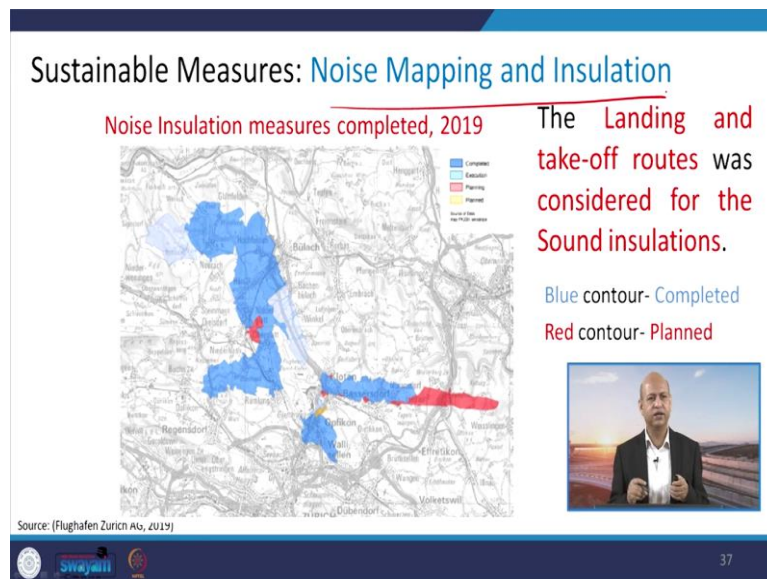
increasing, but the emissions of carbon dioxide is decreasing, so 1997 to 2019 see, around 48,000 tonnes and 25,000 tonnes., so this is the difference between those years.

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Reduction in NO<sub>x</sub> emissions has also achieved because as NO<sub>x</sub> emissions or these emissions have precursors of ozone as well as they also contribute to acid rain etc., so they are harmful and the reduction is a good sign in terms of air pollution management or air pollution control.

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Noise mapping has been there and insulation related activities are taken care of, so during landing and takeoff routes and those sound installation areas they have been managed in a

way that wherever source of noise most is there, then those particular areas can be insulated more profoundly.

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### Sustainable Measures: Photovoltaic Plant



PHOTOVOLTAIC ENERGY  
**1,679 MWh**  
The annual output of all photovoltaic systems was higher than ever in 2019.



Source: (Flughafen Zurich AG, 2019)

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The slide features a large photograph of two workers installing solar panels on a flat roof. To the right, a text box highlights the achievement of 1,679 MWh of annual output, noting it as the highest ever recorded in 2019. A small inset video shows a man in a suit speaking. The slide footer includes the Swayam logo and the number 38.

Photovoltaic plants have been used for generating electricity and using the solar energy, so you never know very high amount like, 1617 megawatt hour and energy is being produced by these photovoltaic cells or plants.

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### Sustainable Measures: Waste water Treatment



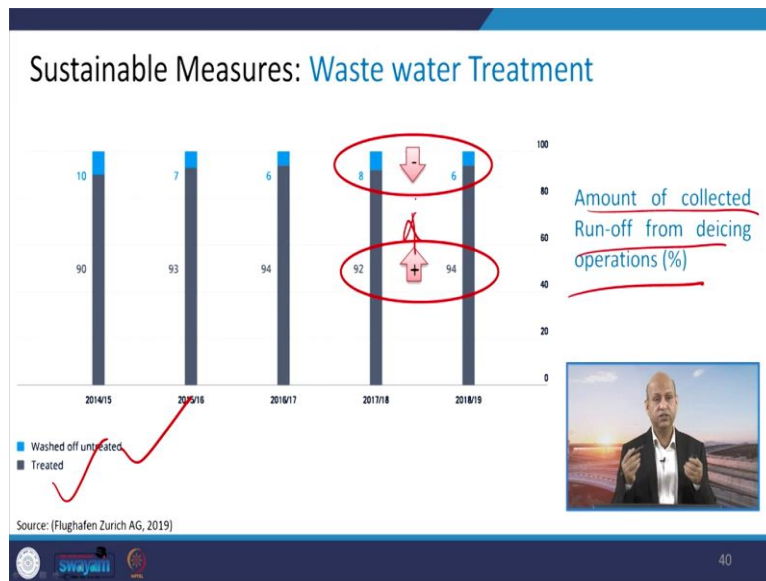
Treatment of Waste water from Deicing operations



Source: (Flughafen Zurich AG, 2019)

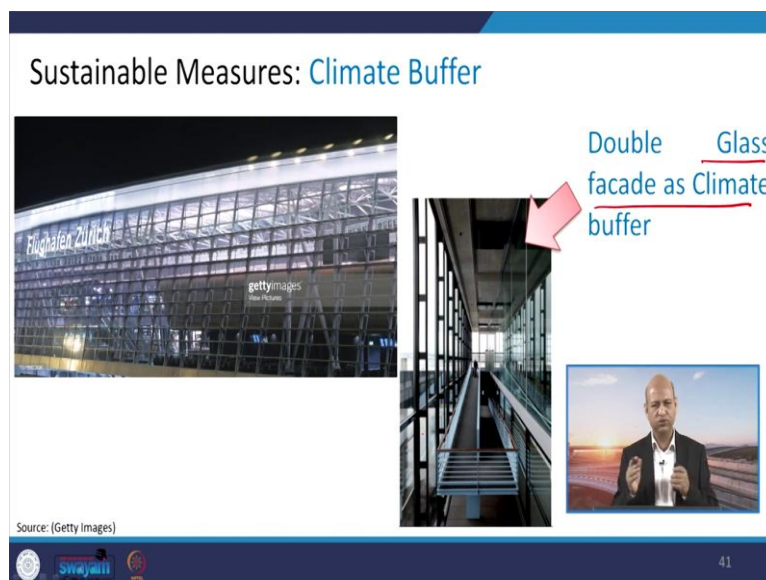
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The slide features a large photograph of a wastewater treatment facility with several large rectangular basins. To the right, a text box describes the treatment of waste water from deicing operations. A small inset video shows a man in a suit speaking. The slide footer includes the Swayam logo and the number 39.



Wastewater treatment, so the wastewater treatment during deicing that particular plant has also been used at that airport and you can see the reduction in amount of collected runoff from the deicing operations, so waste untreated and the treated, so the treated waste is increasing, untreated is decreasing that means again, the capacity has been increased to treat the wastewater.

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There are climate buffers in this, good glasses are being used, special glasses are being used and double glasses, so that if even negative temperature is there outside it will not affect the interior temperature, so those kinds of these air cushion is being used between two walls, those kinds of practices are being used.

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### Amsterdam Airport Schiphol (AMS), Netherlands



- LEED V4 Gold and BREEAM Excellent certified Airport



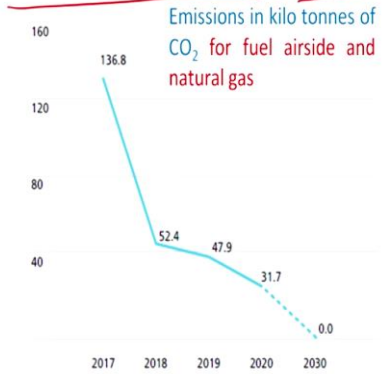
Source: (Royal Schiphol Group, 2020)

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### Towards Zero emissions 2030 initiative

#### Reduced CO<sub>2</sub> emissions and Energy efficiency


Emissions in kilo tonnes of CO<sub>2</sub> for fuel airside and natural gas



Year	Emissions (kilo tonnes of CO <sub>2</sub> )
2017	136.8
2018	52.4
2019	47.9
2020	31.7
2030	0.0




**-18%**  
CO<sub>2</sub> emissions TPI  
Sustainability



**7.0%**  
energy efficiency at  
Schiphol

#### The Transition Pathway Initiative (TPI)

- Global initiative established in 2017 for assessment of Carbon performance of electricity utilities.



Source: (Royal Schiphol Group, 2020)

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In Netherland this Amsterdam Airport this also rated by LEED Gold and then BREEAM excellent that kind of rating system that has achieved and you see why it is so, you can see the reduce CO<sub>2</sub> emissions and energy efficiency, it has like minus 18 % CO<sub>2</sub> means it has reduced and energy efficiency has also been achieved.



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Then there are like around 50 % of the residual flows from airport this waste means earlier it was only 28 % now it has increased to 50 %, so that much of residuals of the waste is being handled at the source segregation being achieved.

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### Hyderabad International Airport (RGIA), India

- One of the very few **Green-status airport**.
- **25% savings in energy and 30% savings in water.**
- **Reuses 100% of treated waste water** generated in the airport for **landscaping, air-conditioning and flushing requirements.**
- **Energy efficiency achieved** through use of high performance glass constructions, high efficient chillers, insulated walls and roof.

Source: (Shireen Kjassim, 2014)

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When we look in Indian context then also there are good airports like Hyderabad, Rajiv Gandhi International Airport Hyderabad this is having green status airport and around it has achieved 25 % savings in energy consumption and 30 % savings in water uses and 100 % wastewater is being used for several purposes like, landscaping or air conditioning and flushing of the toilets etc., so you can see all these greenery as being irrigated by this recycled




water and energy efficiency is achieved by good glass construction because lighting is there, you do not need much interior light, if daylight is coming inside and then insulated walls and roofs are there then, the weather does not affect the interior temperature etc., so that is a good way of managing energy systems.


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### Sustainable Measures at RGIA

- One of very few airport to monitor Indoor air quality.
- Some of green features includes
  - Top soil conservation ✓
  - Electric charging stations in parking lots
  - 100% Rain water harvesting & 100% grey water treatment
  - Fresh air flow maintaining indoor air quality
- 23% Energy savings against ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) baseline
- Use of materials with high recycled content
- Use of green house-keeping chemicals



Source: (<https://www.hyderabad.aero/photo-gallery.aspx>)



Source: (Shireen Kjassim, 2014)

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Then, what are different measures or means for sustainability of this Hyderabad airport, so you can see like soil conservation and 100 % rainwater harvesting 100 % grey water treatment from those our facilities, common facilities, then fresh air management 23 % energy saving, it is being achieved in terms of air conditioning system in a better way management, metal floor recycled content, housekeeping chemicals, all those things have been properly inventory has been prepared and where they can save the chemicals or where they can save the energy those kind of management system has been in place.

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### Sustainable Measures at RGIA: Energy Conservation

Solar panels

Lighting from Solar power

Source: (GMR, 2021)

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In terms of energy conservation solar panels have been used and these lighting from solar power is being used quite in a large scale, so again when we are not using the lighting system from the electricity generated by fossil fuels, we are using from the solar energy that is a big achievement towards the sustainable energy resources uses.

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### Sustainable Measures at RGIA: Waste water Reuse and Recycle

Rainwater harvesting

Sewage Treatment Plant


Source: (GMR, 2021)

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Wastewater reuse and recycle has been achieved because rainwater harvesting is there and sewage treatment plant is there and they are functioning in an optimum way.

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### Sustainable Measures at RGIA: Waste water Reuse and Recycle



The water recycled and treated is used for the green cover at the airport



Source: (GMR, 2021)

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### Sustainable Measures at RGIA: Solid waste Management

- Food waste is converted to **black gold or compost**.
- Manure **used for green cover**.



RGIA does not use chemical fertilizers



Source: (GMR, 2021)

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You see this wastewater use and recycle that is also managed properly and so means, no wastewater is just discarded that is completely used at the airport and some composting and then means there is no use of chemical fertilisers all these greenery is maintained landscaping etc., they are maintained by the compost which is because of the treatment of the waste which is generated there only organic waste etc., so those kind of best practices have been adopted in that particular Airport.

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### Indira Gandhi International Airport (IGI, Terminal 3)

- 8<sup>th</sup> largest Terminal in the World & the largest building under one roof, constructed in India post Independence.
- First Carbon Neutral Airport in Asia-Pacific region
- LEED Gold certified for New Construction (LEED NC), LEED and IGBC Platinum certified for existing building, Green Co. Platinum rated airport, World No. 1 in Airport Service Quality (ASQ) in 2018.
- First Airport globally to achieve ISO 50001 certification.

Source: (GMR, 2018)



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The next is Indira Gandhi International Airport at New Delhi, so this is 8th largest terminal in the world and the largest building under one roof, this says that kind of ranking across the world and first carbon neutral airport in Asia Pacific region, that goes to this IGI airport LEED Gold certified this is, then this IGBC platinum certified and world number one airport in terms of service quality, so there are different ways of ranking the airport, so in service quality, it has got the number one category or ranking and at a global level, this is the first airport which got this ISO 50001 certification for several other services.

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### Sustainable Measures at IGI, Terminal 3

- 336 check-in counters, 78 aerobridges, 3 runways, a 4.43 km long A-380 compatible runway, CAT III B compatibility that allows landing in extremely low visibility conditions
- **The Green initiatives includes:**
  - Integration of efficient emission reduction systems such as Bridge Mounted Equipments (BMEs), Battery operated and CNG vehicles, clean fueling stations etc.
  - 16.6 MLD Sewage Treatment plant
  - 7.84 MW Onsite Solar Photo Voltaic Plant
  - 5 MLD water treatment plant
  - Rain water harvesting and Efficient water management

Source: (GMR, 2018) (Cont'd..)





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Sustainable measure said IGI terminal 3 which is the biggest terminal you can see there are so many counters so there is no crowd and then 78 aerobridges, 3 runways, so condition possibilities not there and then integration of feeders system and efficiency in terms of reduction of air pollution emissions, battery operated vehicles are quite large in number then sewage treatment plant is there for around 17 MLD capacity, solar photovoltaic plant is also there and then water treatment plant for 5 MLD capacity is also there plus rainwater harvesting and water management systems, all those systems are there in IGI airport.

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### Sustainable Measures at IGI, Terminal 3

- Use of Radar sensors for controlling lifts and escalators and Use of over 1200 energy efficient LCD screens for passenger information
- Over 95% construction waste sold for recycling
- 100% natural lighting in departure floor, during day
- 300 rainwater harvesting stations
- Storm water drains to control erosion and sedimentation
- Parking facility with 215 electric charging stations
- Landscaping using recycled sewage treatment plant
- Ecofriendly and biodegradable housekeeping chemicals



Source: (GMR, 2018)

Source: (Shireen KJassim, 2014)

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Similarly, you can see this 300 rainwater harvesting stations within that territory 100 % natural lighting and departure floor that is a good design wonderful design in that so, 95 % construction wastes sold for recycling, so no wastage for landfill etc., it has been sold for some other uses waste to wealth you can call this is storm water drains to control erosion sedimentation, so again the proper design is there it is not just like open drain etc., 215 electric charging stations, these kinds of facilities are there then landscaping using recycled sewage treatment plants water that is treated effluent and eco friendly biodegradable housekeeping is achieved as we have seen in the case of Hyderabad also.



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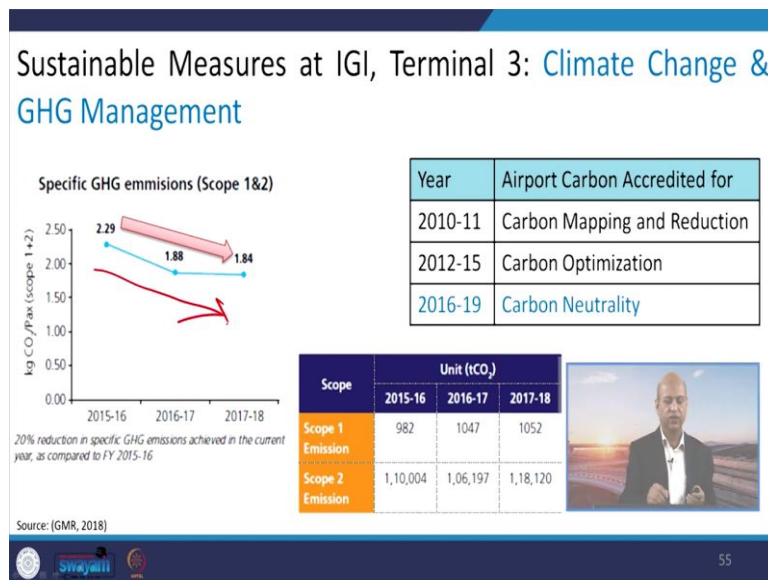


- Best airport for Passenger Service Quality in the World 2018, for airport category > 40 Million Annual passengers handled
- IGI was ranked 101 out of 125 airports in 2007.

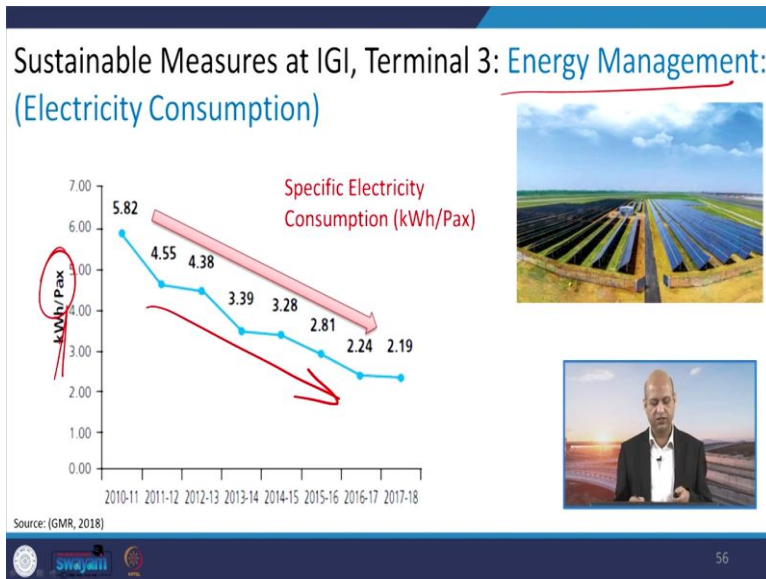


Best airport for passenger service quality in the world that no tag is to this IGI airport, so it was ranked in that way and several ranking systems is there and it is over the years whether it is providing good quality and sustaining that best practice in terms of service quality.

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Climate change and GHG management means greenhouse gas related management's have been there properly and reduction of emissions have been observed over the years, so again this indicates that good practices are there, good technologies are there, so see here energy management is good, energy consumption is decreasing in terms of per passenger kilowatt hour per passenger, so again means passengers are increasing, but means energy management in such a way that it is becoming less intensive and per person consumption of energy is decreasing over the years.

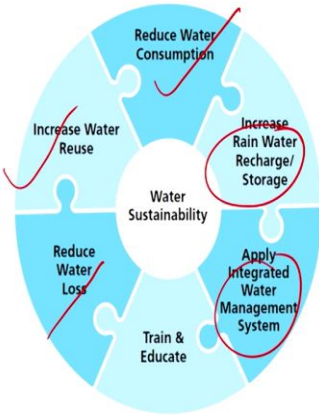
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Waste paper recycling is increasing that means good again practices for collecting and transporting for their better disposal, so those kinds of facilities are in place.

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### Sustainable Measures at IGI, Terminal 3: Water Management



- 300 Rain water harvesting structures
- 5 MLD Water Treatment Plant
- Spill management & Water efficient Storm water management

Source: (GMR, 2018)



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Similarly, if we give an overall view, so the reduced water consumption, increased water reuses and reduction in water losses, and then there are integrated water management systems or rainwater recharge is increasing the storage is increasing, so 300 rainwater harvesting structures have been constructed, 5 MLD water treatment plant is there, a spill management is there, water efficiently, storm water management is there, all these things really go towards best practices of water management.

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### Sustainable Measures at IGI, Terminal 3: Noise Mitigation measures

- Installation of permanent Aircraft Noise and Track Monitoring System (ANTMS)
- Noise abatement runway use plan
- Limitation of use of Reverse thrust
- Restriction on running of aircraft engines while on ground.
- Developing Noise counters by Noise mapping.
- Fixed Electrical Ground power unit to minimize Noise level.



Source: (GMR, 2018)

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Similarly, for noise mitigation, there are measures they have taken and these fixed electrical ground power unit to minimise the noise level, so those kinds of things have been in place.

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You see beautifully landscape this area of terminal three, so that uses those recycled water and treated from their sewage treatment plants treated water that is used for this.

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And in other aspects like ISO management system or green infrastructure programme, green company framework compliance verification programme, all those best practices are there at IGI terminal 3.

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**Conclusion**

- There are **many opportunities to integrate environmental elements** in the planning, designing, construction, operation, maintenance, refurbishment and demolition stages of airports.
- The **Sustainability rating systems act as a guidance** to strive for excellence, minimizing environmental impacts.
- **Huge environmental benefits can be reaped** by the transition of existing airports into Sustainable airports.



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So, in conclusion, we can say that there is lot of opportunity for these airports where a lot of movement of goods and passengers are there, so in construction activities in the designing and then operation from planning to operation those kind of levels or stage stages, all kind of best practices, if we are using then good ranking or good rating can be achieved by those reports and they are known for their sustainable work practices.

Similarly, some kind of excellence aspirations are there because, they compete with each other in terms of service quality and environmental implications, so those things are used by experts and they usage expert services for achieving good environmental practices. So, huge environmental benefits are reaped by these practices and perception also increases good perception alternate also increases.

So, more people come to use the services of that airport, so this is the kind of win win situation in terms of attracting the people and also giving good services to the country and to the society in terms of very less or minimum impact on the environment, so achieving the sustainability aspects or sustainability growth of the public transportation system in terms of airports.

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These are the references for different features which we have discussed in this lecture you can go in detail whenever you have time, so thank you again for your attention and that we have covered three case studies of BRTS, MRTS and now of the airport's, thank you again.