Air Pollution and Control
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Lecture: 20
Emission Inventory

Hello friends, today we will discuss about emission inventories this air quality monitoring gives us idea about what is the status of air quality at a particular place, but if you want to know the quality of a larger area, we cannot put instruments at each corner or at each site. So, we have to do air quality modeling to learn about air quality or air concentration at different points where air quality monitoring is not going to be installed or air quality monitoring equipment's are not going to be installed.

So, there we need air quality modeling, but for air quality modeling, then we want to estimate air quality concentrations ambient air concentrations, we need input data at emissions. So, the emissions are calculated and this emission inventories developed before we do the air quality modeling. So, basically you can say that this emission inventory is the backbone of air quality modeling.

If you do not have a good emission inventory, emissions inventory is nothing but estimation of emissions from different activities, different sectors and we combine and the total emissions in a particular city or a particular industrial cluster or country, country level emissions are also reported to international agencies like if you want to control greenhouse gas emissions.

So, every country has to report to a particular agency that this much of greenhouse gas emissions are occurring in our country. So, the emission inventories developed regularly because emission change year by year due to technology change, due to land use and land planning change. So, there are several reasons why we need to have emission inventory at a periodical intervals. So, in today's lecture, we will see what is the emission inventory, what is its importance, what is its role in air quality management.

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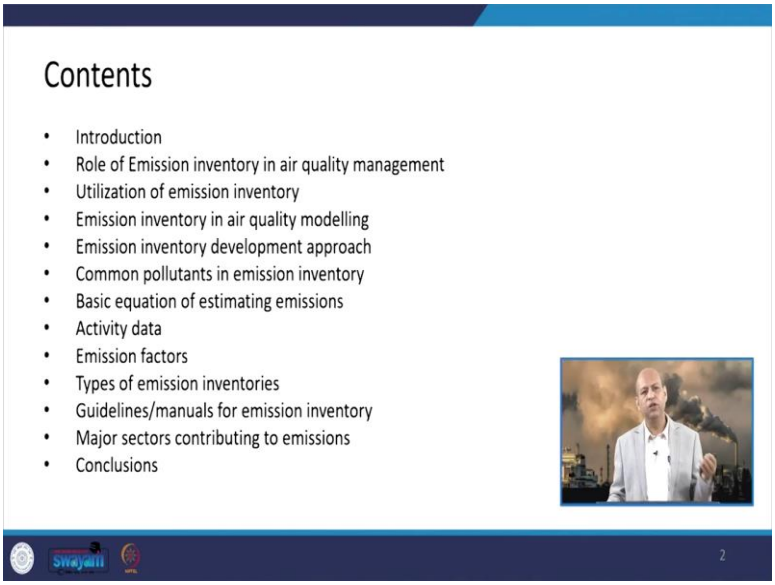

And how it is developed basic what are the basic fundamental approaches which we use for development of emission inventory and those basic equations which we use. And then what are the activity data which are, we consider for estimating emissions for each activity data, then types of emission inventories, because, several researchers and several agencies have given some sort of methodology for developing emission inventory.

So, we will see different kinds of emission inventories which are available. Then guidelines and manual so, permission inventories which have been proposed by different agencies and the major sectors which contribute to emissions and the sector wise emission inventory we will see later on, but today it is only introductory lecture about emission inventory and its different aspects.

So, when we talk about emission inventory, it is a brief introduction then basically we talk about air quality management because this is one of the fundamental aspect or component of the air quality management. In air quality management, we need to monitor year then we need to run some models because at every corner we cannot install instruments to measure the air quality.

So, at different places, we want to have the air quality measurement, but at other places you can calculate the air quality or ambient air concentration. So, for calculating ambient air concentration through some air quality model, we need emissions. Emissions are the input values for air quality models like dispersion models etc. So, basically we need to develop inventory of emissions.

We need to estimate calculate emissions from different sources for example, you want to know what is the effect of some thermal power plant at a particular place. So, background air quality is there and that air quality is because of those background sources of air pollution that may be from industries, from domestic transportation sector or some other plants etc.

So, you estimate emissions of all those activities and then you sum up them. So, that is the total emission in that location. When additional source you wants to install, then you have to add that also then you calculate the air quality concentration, ambient air concentration by running a model. So, those emissions can change as per the land use and land planning that is why the emission inventories are developed very periodically after some years because technology changes, so, emissions also change.

So, emission inventory is a dynamic process it is not that you have developed once one emission inventory and it will go for years, you have to incorporate the changes which have been in some technology or policy related issues, land use related issues that influence the total emissions at a particular place. So, that is why we say that emission inventories is one of the fundamental components of total air quality management to major changes over time to achieve that cleaner air. So, you can see in this picture also.

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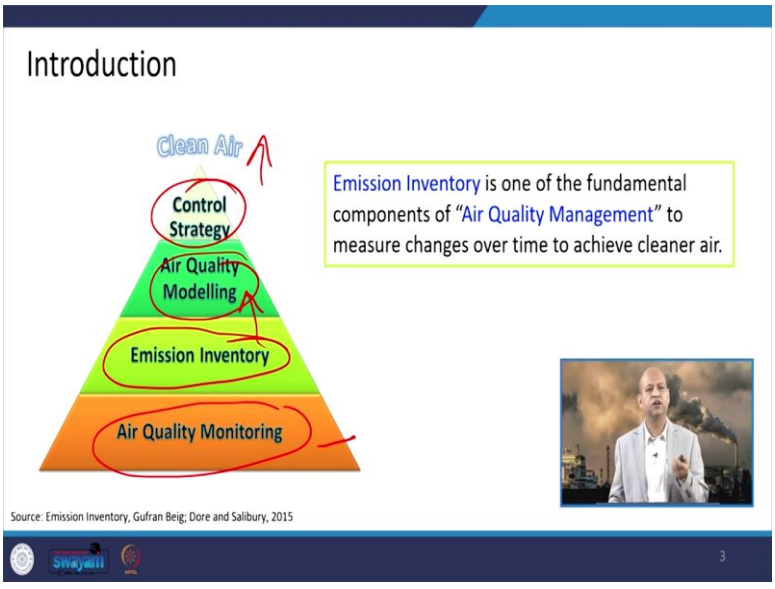

Air quality monitoring is the basic thing, then emission inventory has to be there, so, that you can use the air quality model and control strategies depending upon what is the air quality concentration as per different scenarios and you can achieve the clean air by changing those emissions, which you get figures from emission inventory.

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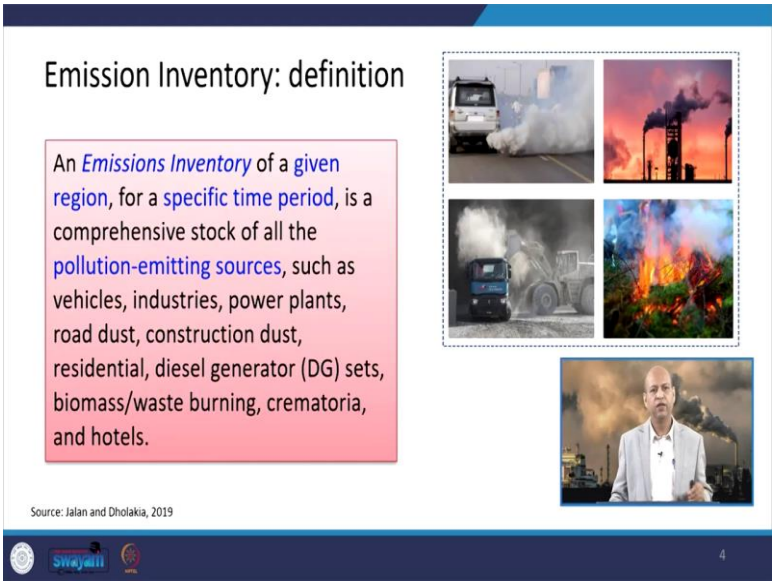

When like we want to define what is the emission inventory related to a given sector or activity. So, you can see that the emission inventory of a given region for a specific time period like for per hour or per day or per season or per year is a comprehensive is stock of all the pollution emitting sources.

For example, vehicles, industries, power plants, road dust, construction dust, construction activities related dust emissions, residential emissions, diesel generators and then biomass burning, waste burning all those from hotels, commercial activities from every source, you get the emissions you sum up, you develop the emission inventory. And then you use that emission inventory for this air quality modeling.

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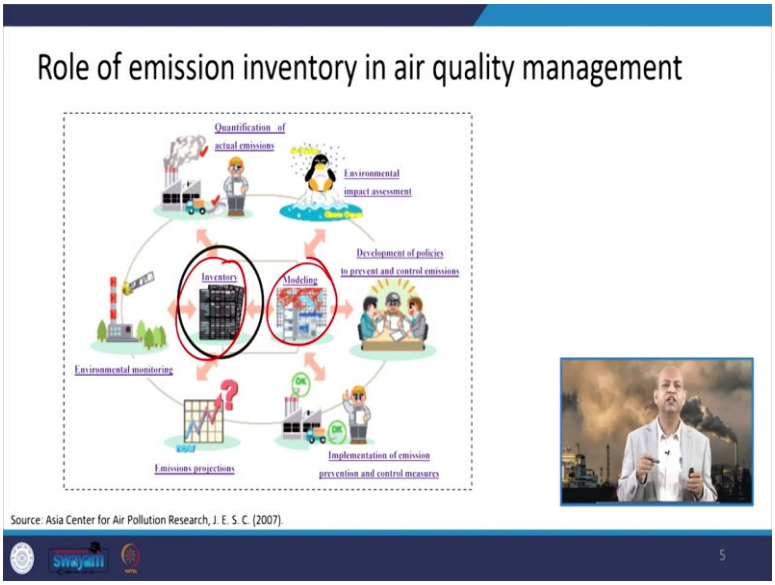

And that emission inventory can be like per unit of time like total emissions of this Giga gram per year, but you want to have grid based emission inventory which we will see why it is important for air quality modeling. So, the role of emission inventory in air quality management is depicted by this particular figure, where you can see the modeling, it is related to inventory.

Otherwise, there are so many activities like quantification of actual emissions and governmental impact assessment, development of policies to prevent and control emissions, all those things are interrelated because emission inventory gives input values to the modeling and modeling gives you certain concentrations of ambient air in pollutants in the ambient air.

And then when you have the time series of those emissions and air quality related the values or ambient air concentrations, then you can learn that a particular pollutant is increasing or decreasing. And if it is increasing, what is the region, if it is decreasing what kind of changes we have incorporated in our technology or fuel or some other activity, so, that the reduction is there. So, those impact of policies can also be evaluated assessed by these kinds of activities.

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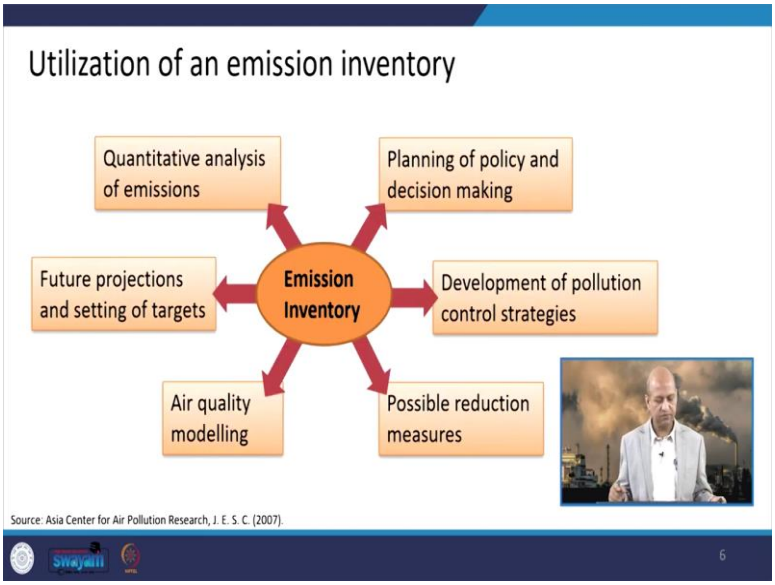

So, the utilization of an emission inventory is manifold like it can be used for planning of policy or decision making, because you want to change. For example, like in Delhi, you want to change this public transport system to a particular fuel like CNG it was implemented. So, how much gain will be there in reduction of particulate matter. So, these emission inventories helping these kind of estimations.

If you want to change complete those road vehicles to electric vehicles, then what will be the emissions of those non exhaust emissions like from road dust or from tires etc only those emissions what will be the changes or you can reduce the exhaust emissions because of change in particular emission inventory as per the policy and programs. Development or pollution control strategies, so, as I said whatever control strategy we apply, it will reduce emissions.

So, those emission inventories will be as per the control strategies, two stroke engine, it is converted to four stroke engine, so, emission will change. So, accordingly emission inventory will take these kinds of changes and this spreadsheet modeling or other complex modeling can also be there for emission inventory because emission inventory is also developed by certain models.

It is not only simple calculation, but sometimes it needs a lot of sophistication also. Possible reduction measures and the air quality modeling or future projections you want to have, according to this, targets or quantitative analysis of emissions whether it is decreasing increasing, its impact on air quality, then its impact on health risk, all those things can be related to the emission inventory. So, the utilization of emission inventory is manifold.

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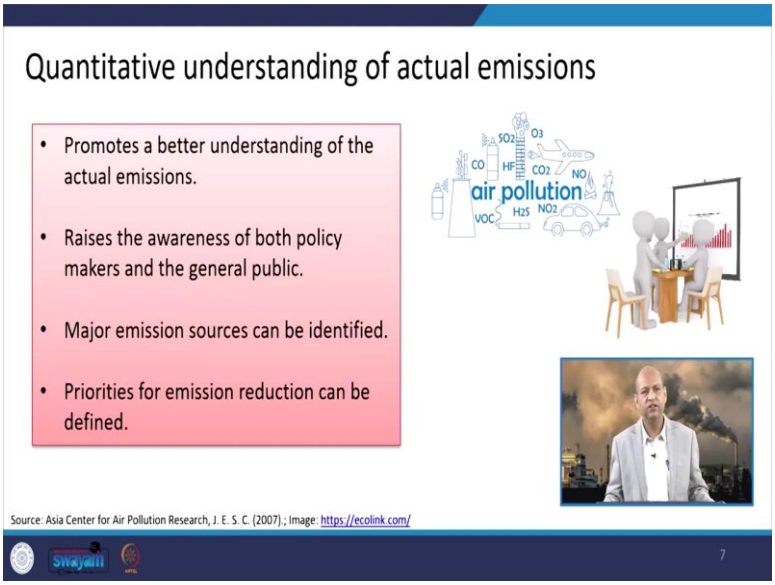

Then it also helps in like promoting better understanding of the actual emissions without if we do not have the real figures, the actual values, we cannot really judge whether, the impact is more or less for example, earlier people used to say that the transport sector is the sole responsible for the poor air quality in Delhi. But later on when emission inventories were developed and it was found that pollutant wise different sectors have different significance.

So, particulate matters were very much released by power plants. So, those kind of when you have some perception, but that perception can be changed when you have the actual values, although emission inventory development is also an estimation kind of thing, you can never reach the actual or absolute value, you have this estimation based on your certain data and then it also raises the awareness of both policymakers and general public.

Because for a particular city, let us say, you are having the emission inventory for different sectors. So, with that sector, you will be able to judge, which sector is responsible for a particular pollutants increase or decrease, if like PM_{10} you want to target and PM_{10} is coming from a particular activity A and in comparison to the activity B. So, better you target the A to reduce the PM_{10}.

Then similarly, there are other modeling efforts for secondary aerosol generation. So, that is also important that what are the precursors, which are resulting in secondary aerosols. So, can we reduce those precursors? So, those kinds of things are also important and the, this quantitative understanding of actual emissions through emission inventory help us to get that. Major emission sources can be identified as I just said about that A and B.

Priorities for emission reduction can be defined by that emission inventory because it will give you an information that this is the sector. This is the activity which is emitting the maximum emission of a particular pollutant. So, better target that. Otherwise you will have certain amount of money and if you distribute for each sector, you improve, but the improvement in air quality will not be visible, because we are not tackling that particular sector which is predominantly responsible for a particular pollutants emissions.

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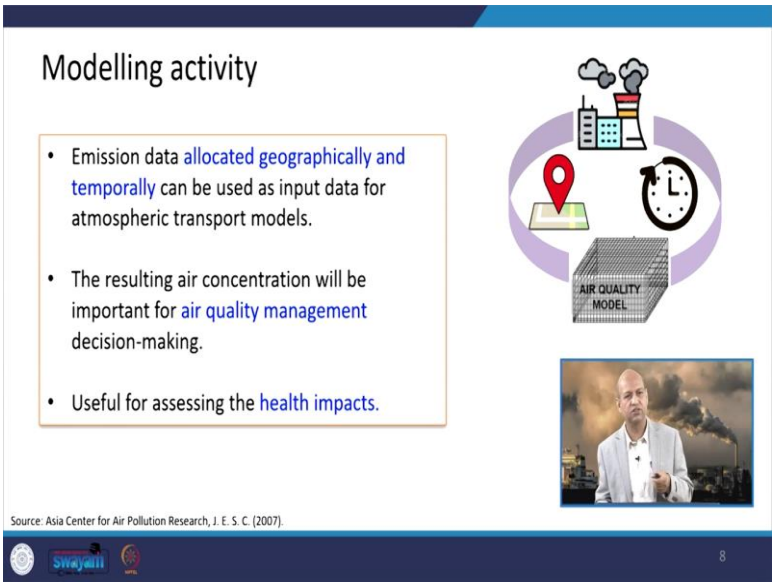

And the emission inventory helps us to understand that the comparison of different sources. Well, so, the modeling activities, the emission data, allocated geographically and temporally means spatially, and with respect to time it can help or it can be used as input data for atmospheric transport models and atmospheric dispersion models also. The resulting air concentration will be important for air quality management decision making.

Because, emissions will decrease accordingly, the air quality will vary, the ambient air concentration will vary, and then we can see which is more important and which is least important as per their concentrations, whether they are exceeding, the ambient air concentration standards or not. Then it can also be used for assessing the health impact because once the concentrations, you can convert it into the health impacts also by using certain equations by using certain models.

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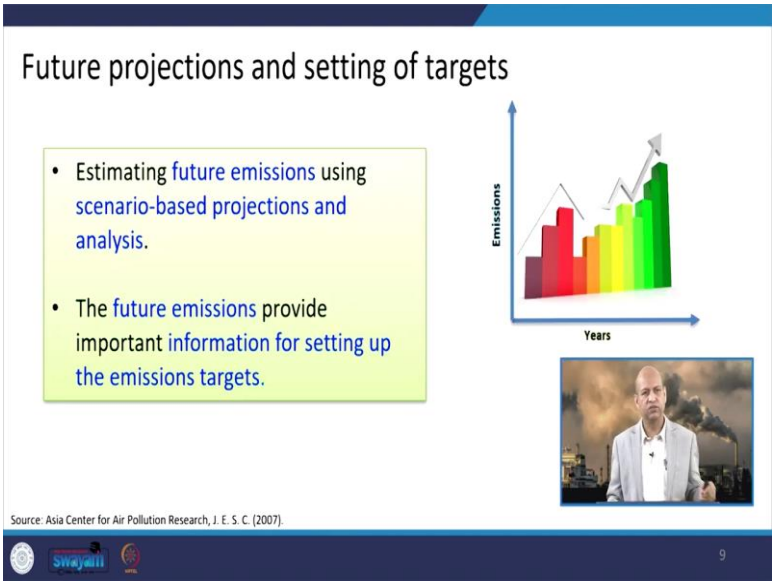

Well, other future projections and setting of the targets are also very important activity like you estimate the future emissions for example, you can see after 10 years, what will the emission of this particular city, so, you look at what kind of activities will increase or decrease accordingly different scenarios you will create and based on those scenarios, you can make the projections and you can analyze whether certain pollutants will increase or decrease.

Accordingly, you can look at the policies and programs depending upon the projections. So, the future emissions which can provide important information for setting up some emission targets for example, let us say because of this electric vehicles, a particular pollutant like NOx emissions reduce then it is good. So, that means, other sectors we can concentrate upon for other pollutants rather than NOx or so.

And it can also influence like ozone production is being influenced by it or not. Those modeling techniques can also give us additional information by incorporating those kind of gases or precursors.

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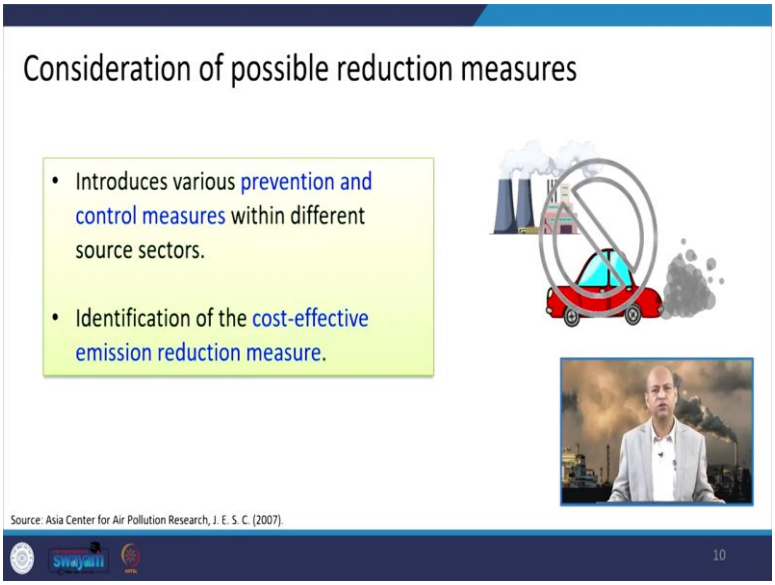

Well when we consider the possible reduction measures, then also it is important because the prevention and control measures, how will you know that whether it is working or not, again emission inventories, because emission inventories will incorporate those changes those control measures. For example, power plants, if you are having, let us say this ESP to control emissions, so, what is the efficiency of that ESP?

Accordingly, the emissions will be changed and your emission inventory will change. So, the cost effective emission reduction measures can also be assessed by emission inventories, because you can put different technologies and see what is the emission and accordingly when you compare you choose the best technology which gives the least emissions.

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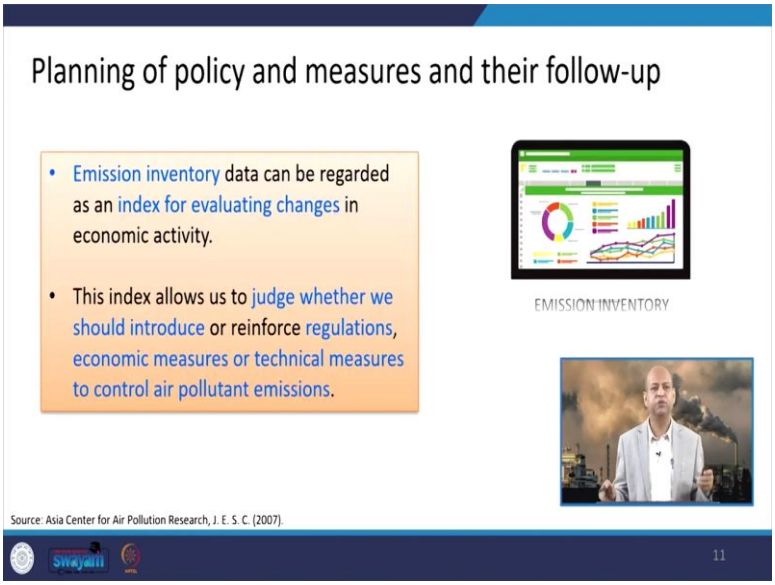

When we plan some policy and majors and we want to follow up them their impact again these emission inventories help us to rely upon the decision making process because it will give the data and accordingly we can judge whether that policy is effective or not.

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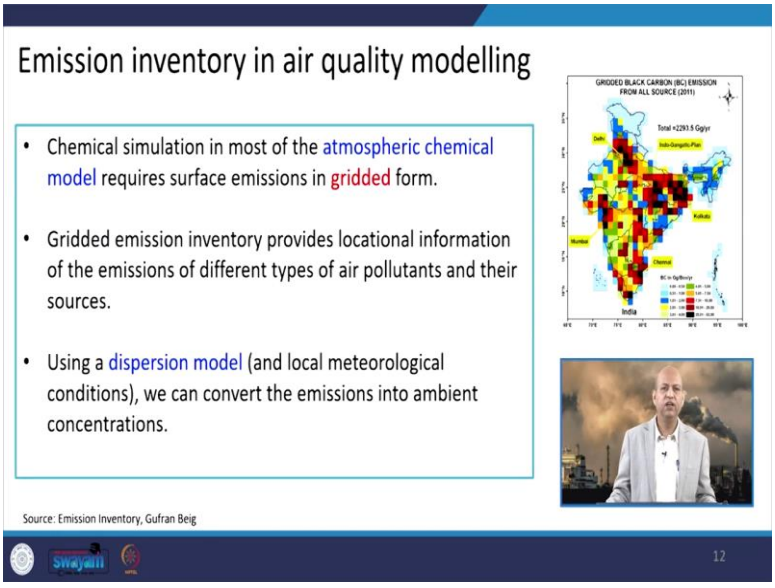

Well, when we talk about air quality modeling, we need gridded emissions because we can calculate emissions as a single value, but we have to divide it according to the activities. In a city also different pockets can have different emissions in industrial areas, they will have different kinds of emissions, where roads are there then you will have more CO NOx emissions, where power plants are nearer you will have different kinds of emissions.

So, the grid emissions are divided according to the activity data. So, the chemical simulation in most of the atmospheric chemical models requires surface emissions in gridded form like these kinds of grid square 1 x 1 kilometer, 2 x 2 kilometer depending upon how much data you have. Those gridded emission inventory provides locational information of the emissions of different types of air pollutants and their sources.

And using a dispersion model and local metrological conditions, we can convert those emissions into ambient air concentrations. So, that will give us the real situation in which particular location of the city which kind of pollutant will be more. So, according to we can suggest some changes in the behavior of the people also. Suppose, according to the metrological data and the emission, you find that only certain sunshine is good and ozone production maybe higher in a particular location.

So, you can always warm that, the old people and those people who are having some health issues, they should not visit that particular location, where according to your modeling the ozone, concentration may increase because of some precursors.

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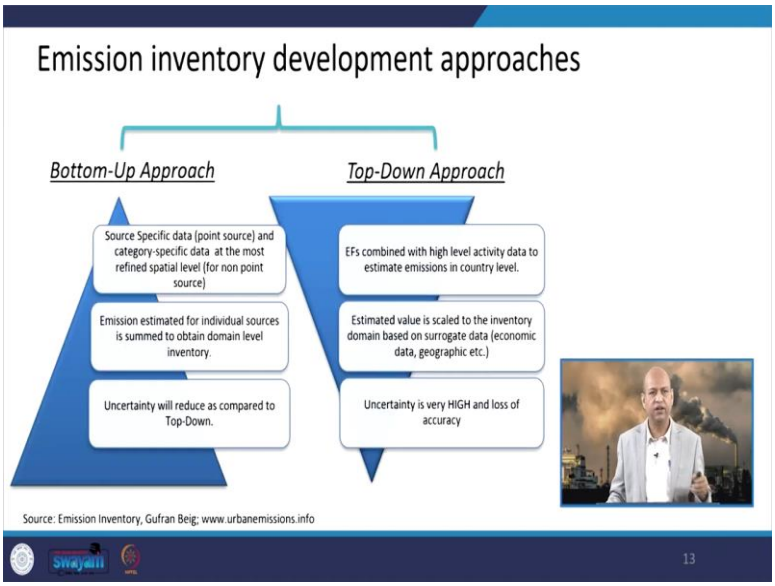

So, the emission inventory development approaches also are different like bottom up approach or top down approach. So, in bottom up approach, basically we go for detailed activity data. So, it is very data intensive you can say extensive data set we need. For example, let us say we want to develop emission inventory for a transportation sector. So, from bottom up approach you need detailed like values of how many vehicles are there within those vehicles, how many four wheeler, how many two wheeler, within two wheeler how many two stroke, how many four stroke.

Within four wheeler, how many are driven by diesel or gasoline that is petrol or CNG those kinds of things, as much data you have as much as you can that will help to develop more realistic emission inventory that is the bottom of approach so, that you survey you get the data primary data, you use them and develop the emission inventory that will be more realistic.

Top down approach means by surrogate parameters, like for example, for a city how much diesel was sold. So, then there are some thumb rules that, this much of diesel burning in transport sector, this much of emission is occurring of a particular pollutant then you distribute. So, that top down approach may be there or satellite data you have and you have some air quality concentration in a column, you want to distribute it for other activities.

So, those inverse modeling can be done. So, those are the things that top down approaches are sometimes coarser and it is not as detailed as the bottom up approach, but for like preliminary decision making top down approach can be quicker, those kinds of things are there to differentiate between the two.

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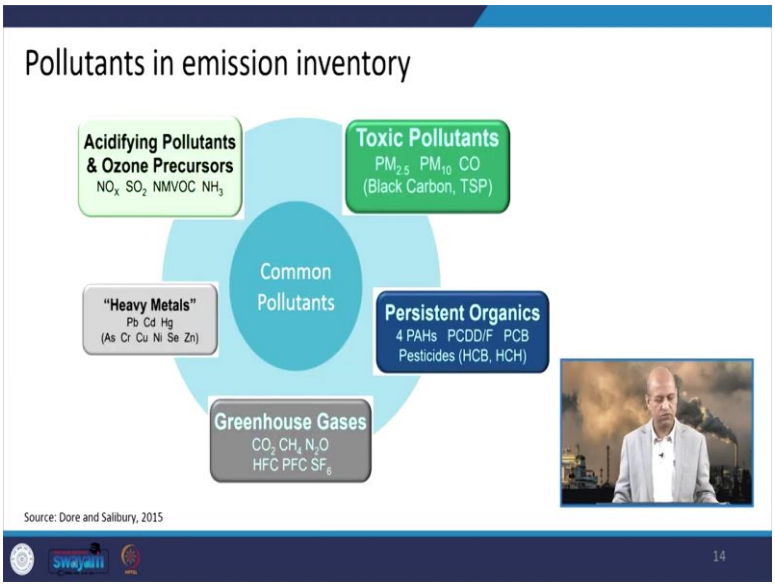

Well, so the pollutants and this emission inventory, we consider depend upon what is the use of the emission inventory. So, if you want to know, you want to run a model to see the acid rain effect then acidifying pollutants you can develop emission inventory, NOx, SOx, etc. If you want to see the health impacts, etc of particulate matters CO etc. Then you can have these toxic pollutants.

Then heavy metals related emission inventory you can develop, you can develop persistent organics related emission inventory or greenhouse gas related emission inventory. So, it can vary depending upon what is the use, what is the problem we want to solve, if you want to have the emission inventory of all pollutant, you can have it and depending upon how many resources how much resources you have.

Because, whatever activity will do you will require a lot of resources trained people then for survey, for collection of data a lot of resources are needed. So, there are limitations also you cannot go for every kind of thing, unless you have a lot of resources for that particular activity.

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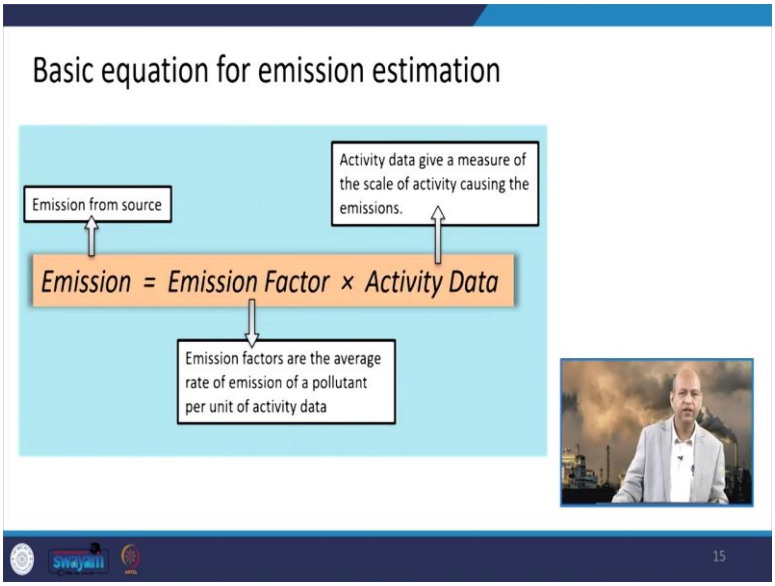

Then when we talk about basic equation of the emission estimation that is very simple, like emission is nothing but the emission factor into activity data like emission factor means for example, for vehicular emission inventory. You want to know when a scooter is running 1 kilometer, how much emission of CO is coming. So, the emission gram per kilometer, milligram per kilometer depending upon different pollutants and for power plants etc you can have like a coal is burning.

So, one kg coal burning how much emission is there. So, per unit of weight or mass you can have the emission factors. So, depending upon the activity emission factors you can have and then the total activity data you multiply means for vehicles, how many kilometers per day it will run. So, you can multiply that distance traveled for coal burning power plant how much coal will be burned in a day.

So, for that daily emission inventory or annual emission inventory depending upon you can multiply those figures and get the emission data.

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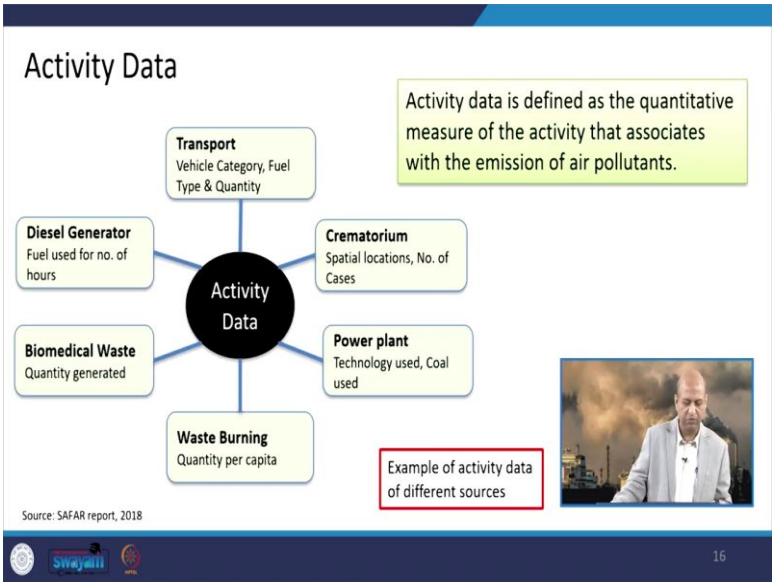

And these are the activity data as like transport. So, in transport vehicle categories as I said fuel types and the quantity all those things are there. Well power plants what kind of technology is being used, whether it is a gas based power plant or coal based power plant, then waste burning. So, quantity per capita again different cities have different values for that middle class, lower class they have different kind of lifestyle.

So, different amount of waste is generated different type of waste is generated then biomedical waste from hospitals etc labs and then diesel generator. So, you just imagine the activity. This is just a representative of these activities, but you can add whatever you want and the activity data can be extended in that way.

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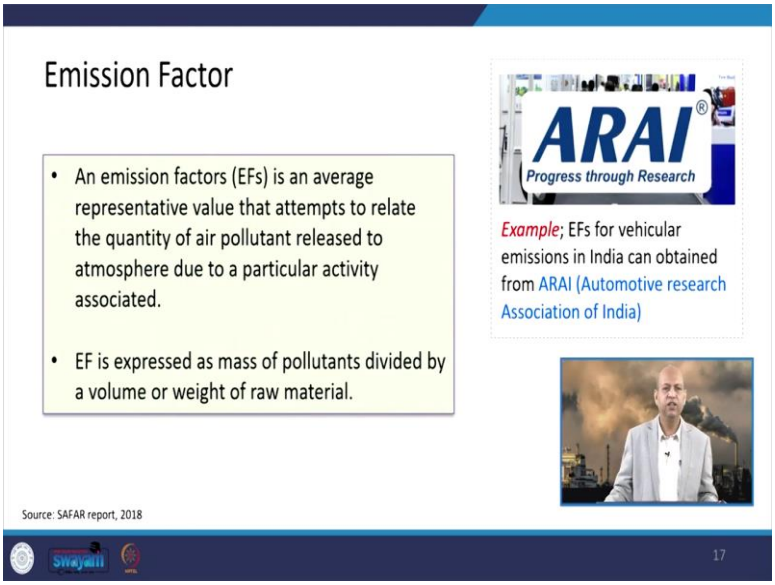

Well, the emission factor as I said it is nothing but an average representative value that attempts to relate the quantity of air pollutant released in the atmosphere from a particular activity. So, it can be per kilometer driven of a vehicle or per kg of the coal burned something like that.

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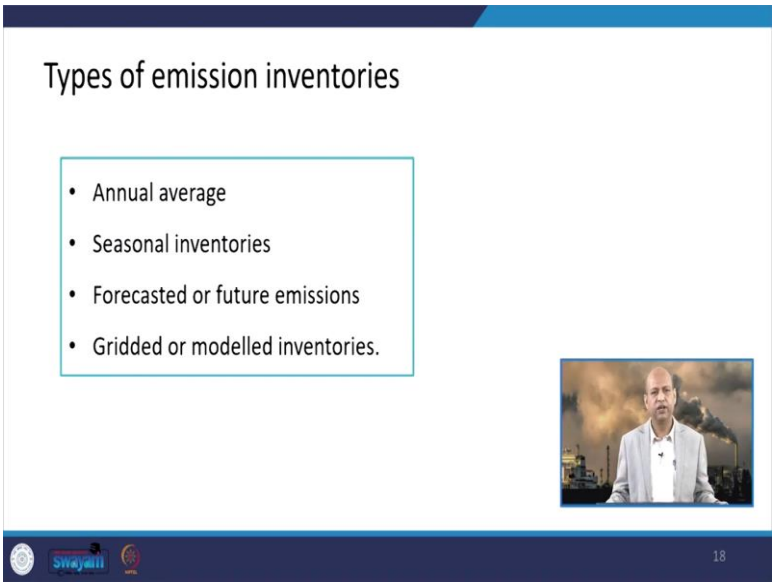

And the types of emission inventories can be like annual average or seasonal inventories or the forecast or future emissions related emission inventories, gridded or model emission inventories, greenhouse gas emission inventories, you name the purpose and the pollutant or the region accordingly, the emission inventory can also vary.

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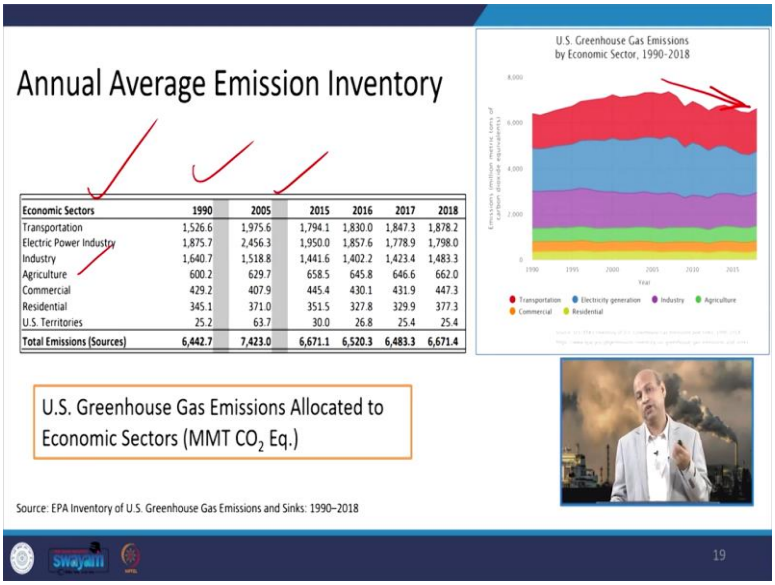

When we talk about annual average emission inventory. So, this is one example for like US greenhouse gas emissions, this economy by economic sector from 1990 to 2018, you can see the variation. So, when you have the yearly emission inventory, you have different values, so, it also gives the trend. So, this transportation trend you can see in 2010, 2015 it is reducing.

So, you can see what is the region whether it is the fuel efficiencies better in those new vehicles or the population is shifting from particular kind of vehicle to other public transportation system or the technology is better, those kinds of things you can always look into. And economic sectors could be like transportation, electric power industry, industry, agriculture, so, different years, different activity and according to different emissions.

But when you have the time series of emissions, you can always come to this kind of insight that some pollutants are increasing or decreasing and why they are increasing or decreasing and if they are decreasing then that kind of technology we can further use or extend and if it is increasing then we have to make certain changes.

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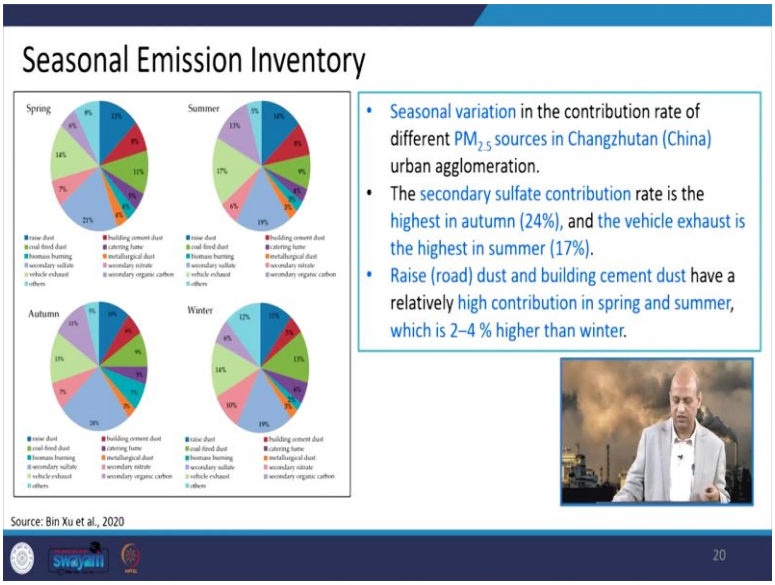

So, that pollution does not increase constantly. Like seasonal emission inventory you can see here, if we compare like spring season, summer season, autumn and winter. So, here also like seasonal variation is visible. So, contribution rate for this $PM_{2.5}$. It is shown in this particular figure, and the secondary sulfate contribution rate is the highest in autumn you can see 24 percent around and the vehicle exhaust is highest in summer.

So, according to season which particular activity is more responsible for a particular pollutant up to what extent? Then the road dust and the buildings, cement, dust have a relatively high contribution in the spring and summer, which 2 to 4 percent higher than the winter. So, those kind of insights or inferences you can always draw from such kind of figures, which are based on seasonal emission inventory or temporal emission inventory.

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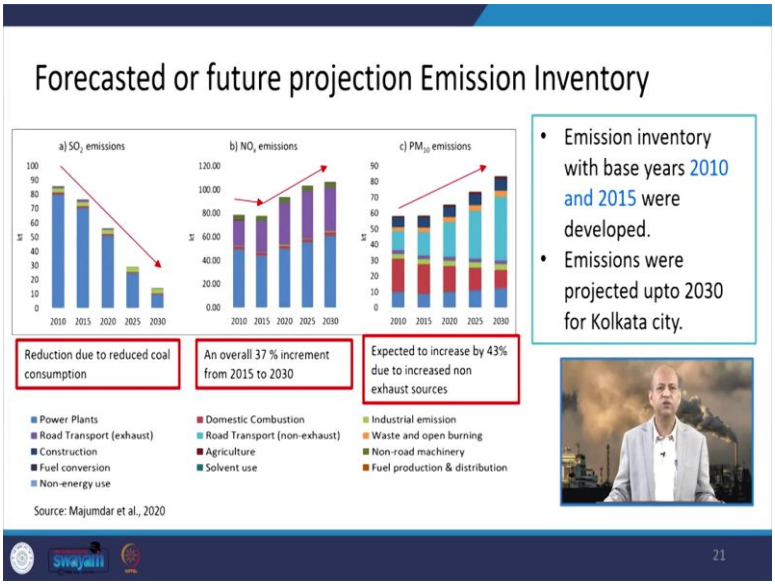

When you talk about forecasted or future projections of emission inventory. So, you will have these kinds of data for different years like from 2010 to 2030. So, projections are there for future. So, here reduction due to reduced coal consumption in SO_2 emissions is visible. So, those kinds of policies are coming up that we are shifting from away from the coal utilization then the SO_2 emissions are being shown as decreasing trend.

In this NOx emissions, 2010 to 2015, little bit decrease, but then again it is increasing. So, what is the reason for that we have to see? So, different you can see this is like power plant or road transport or those kinds of things, you can see the road transport emissions are increasing exhaust emissions are increasing. So, that is that will be the responsible if that particular policy is being followed maybe it is not considering though those electric vehicle kind of thing. PM_{10} emissions are also like, these are being increased in increasing trend.

So, this is for Kolkata city basically, one sample study you can see, so, that the emission inventories, base year is 2010 and the projections are for 2015 and 2030. So, accordingly the trends can be analyzed and you can link those trends with the particular regions and you can address those reasons if you need.

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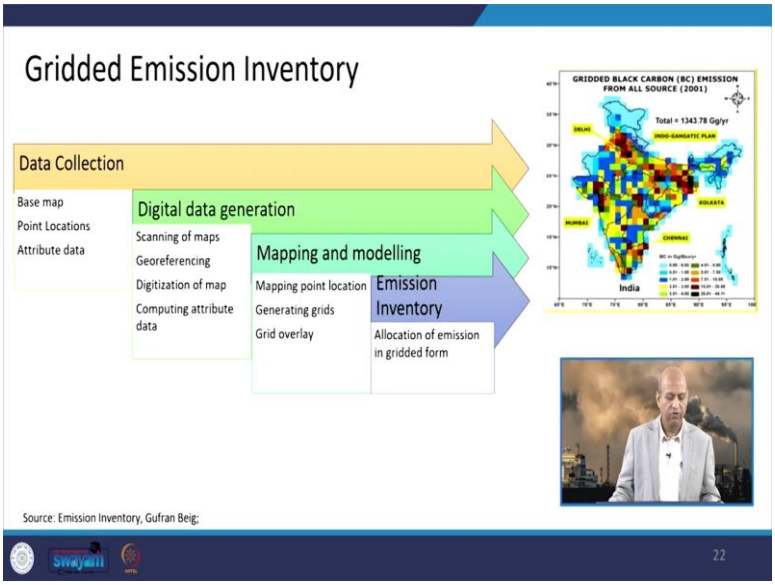

Well gridded emission inventory is important as I said, because different kinds of models need gridded emission inventories to pick from like for a country or for a city whatever you are taking, so, the data collection like base map or point locations, attribute data, then digital data generation, scanning of the maps and geo referencing, digitization of the map and computing attribute data those kinds of things you have to consider.

And then then mapping and modeling, so, mapping point locations, generating grids and grid overlay and then you allocate the emissions for different grids. So, that is the way to develop the emission inventory in a gridded form, you can have total emission, but if you want to distribute in different grids, then you have to follow this kind of procedure.

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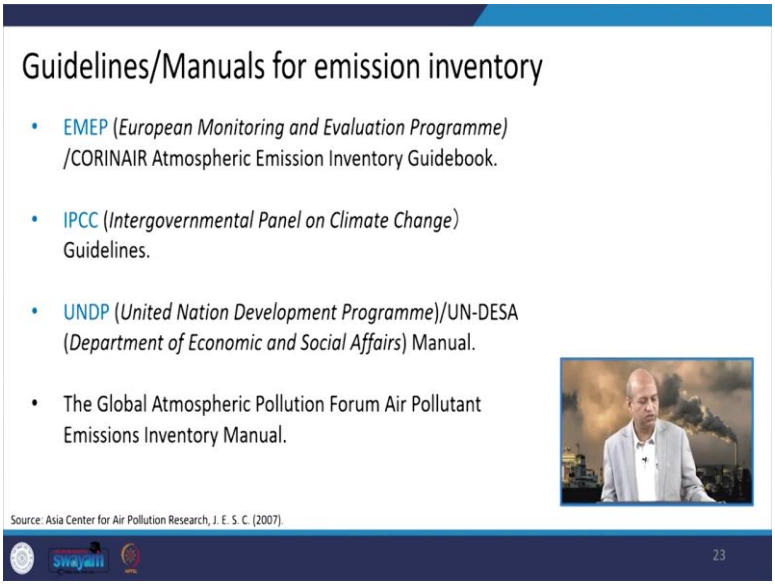

Well, there are different agencies, which have provided certain guidelines or manuals, because emission inventory development, if you want to have uniform policy measures, and the suppose, you are asking different countries to pull their emission in a particular agency, then you have to provide them some guidelines, so otherwise, people will have different kind of methodologies and you never know that, how much uncertainty is there in that emission inventory which they are submitting.

So, guidelines and manuals of emission inventories have been prescribed by different agencies like European monitoring and evaluation program, it gives this atmospheric emission inventory guidebook. Similarly, IPCC intergovernmental panel on climate change. So, for greenhouse gas related emission inventories, which they invite from different countries member countries. So, the guidelines are given there. Those particular emission factors they have to use according to the activity.

Then UNDP, United Nations Development Program, so, this gives department of economic and social affairs manual. Similarly, the global atmospheric pollution forum, air pollutant emission inventory manual is there.

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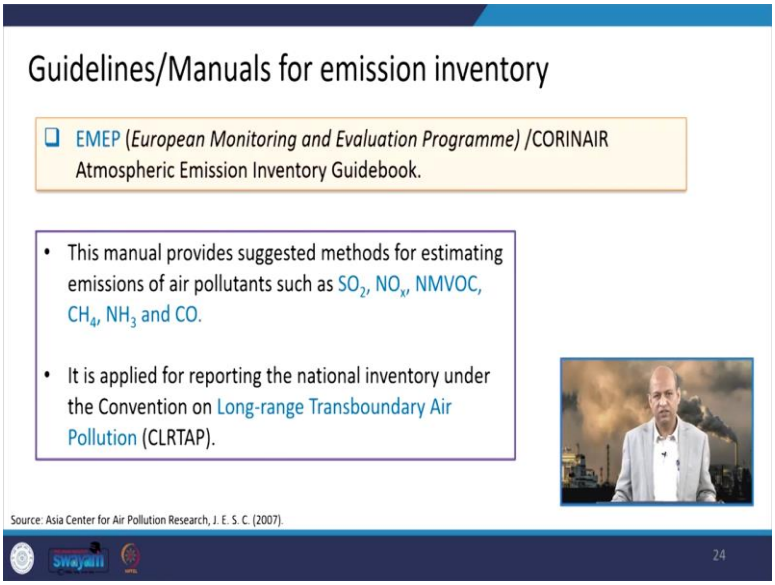

And if we look at those guidelines, so, like for example, EMEP like European monitoring evolution program, that gives manuals for these particular pollutants like SO_2, NOx, NMVOC that is known within VOC, VOC is volatile organic compounds, then methane or ammonia and CO and it is applied for reporting the national inventory and the convention on long range transboundary air pollution.

So, that is particular program and under that program when different countries member countries submit the emission inventory. So, this particular guideline or manual they have to follow.

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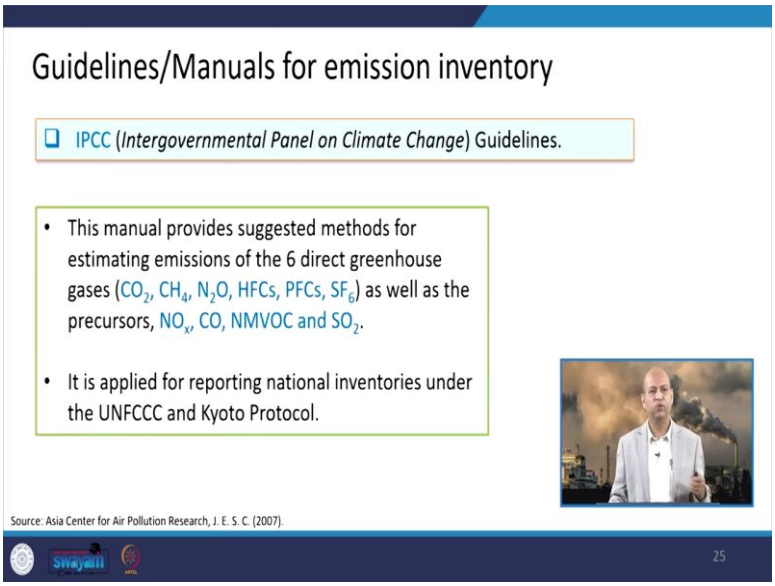

Similarly, in IPCC as I said the member countries have to follow to submit to UNFCC as per the guidelines which have been prescribed by IPCC.

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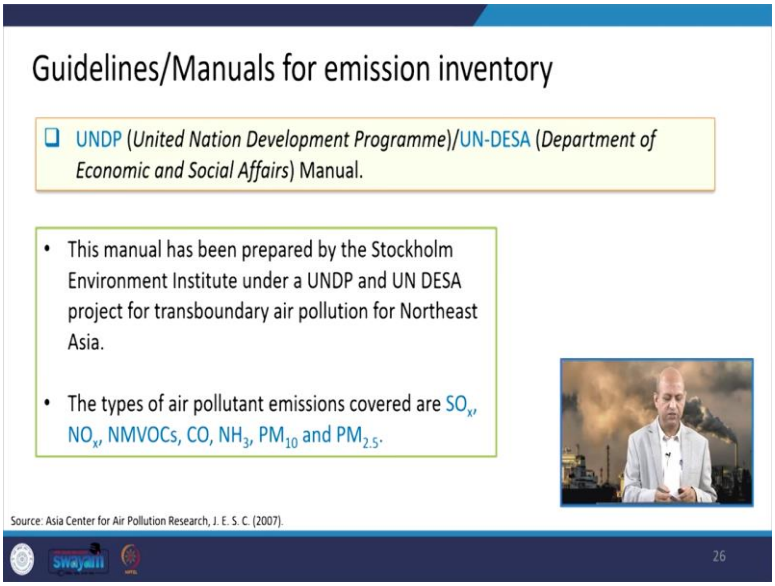

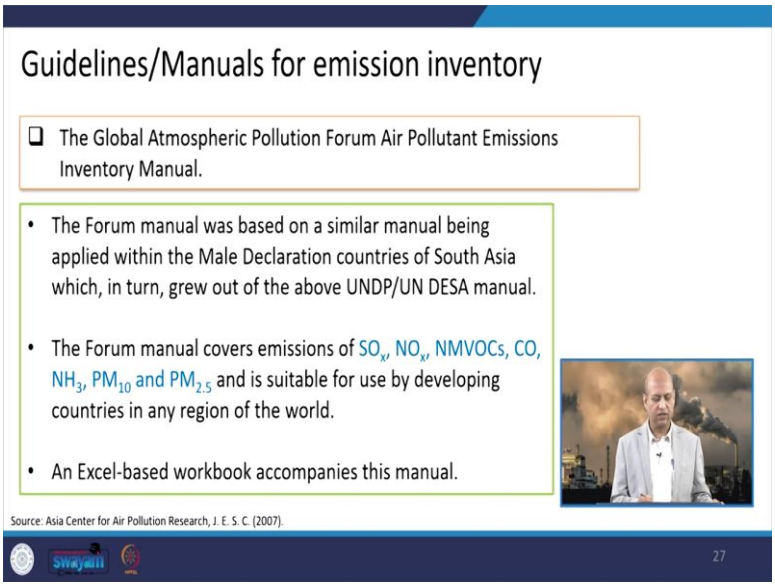

That happens in case of UNDP also, which have different manual for these SOx, NOx and VOCs you etc. So, every agency has a set of pollutants for that they need emission inventories and for that they give the this guidelines.

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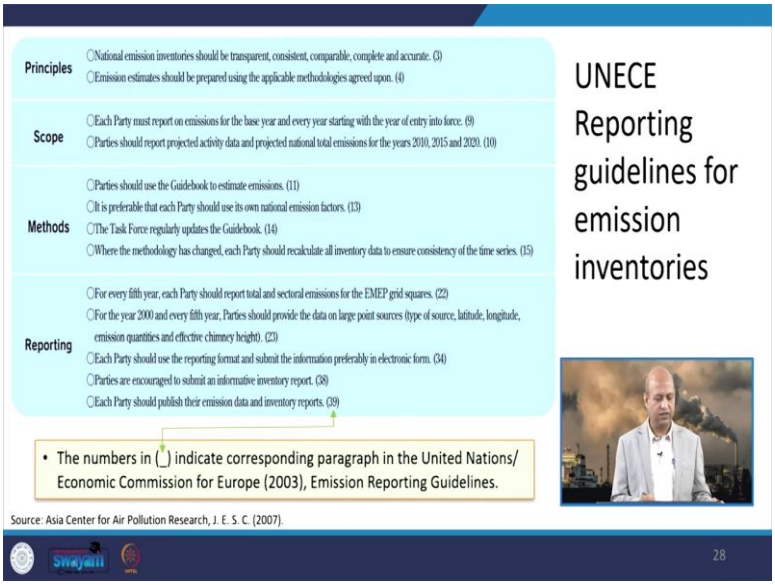

Now, here you can see this UNECE reporting guidelines for emission inventories. So, the principles are given. So, as a representative thing, just we want to give you an introduction, what are the scopes like each party must report on emissions for the base year and every year is starting with the year of entry into force. So, these are the guidelines, they have to follow religiously.

Methods is also given and the reporting wage also given the numbers within the bracket indicate corresponding paragraph in the that particular guidelines would say just a guideline and only basis on the basis of that guideline people develop emission inventory, different departments are there in each country, they are responsible for submitting those emission inventories.

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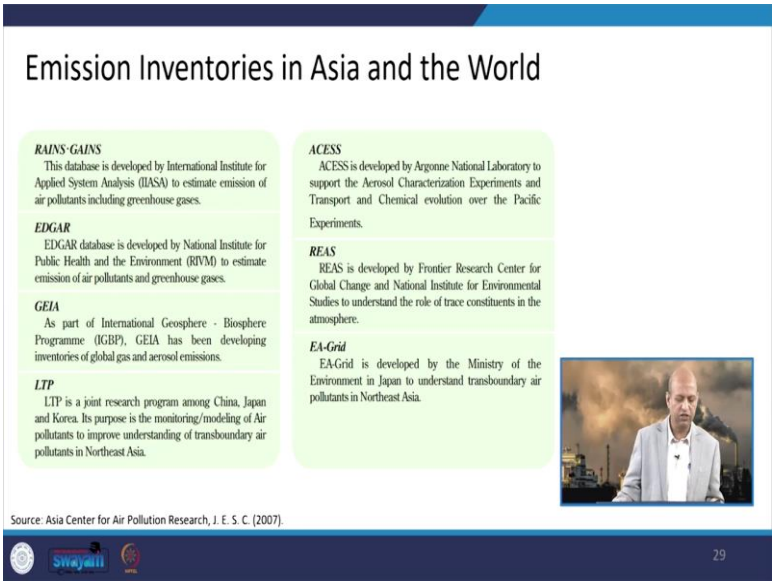

So, now, if you want to see different kinds of emission inventories, which are available in Asia and the world, so, there are several names like RAINS-GAINS. So, this is database which is developed by International Institute for applied system analysis which is in Austria to estimate emissions of air pollutants including greenhouse gases. Similarly, EDGAR is the EDGAR database is developed by National Institute for Public Health and the Environment to estimate emissions of air pollutants and greenhouse gases.

Similarly, GEIA is there, LTP, ACESS, REAS, EA-Grid. So, different kinds of set of pollutants have been considered in these emission inventories. And worldwide these emission inventories are used by researchers and a lot of efforts are made to revise these emission inventories. So, that latest emissions are available for researchers.

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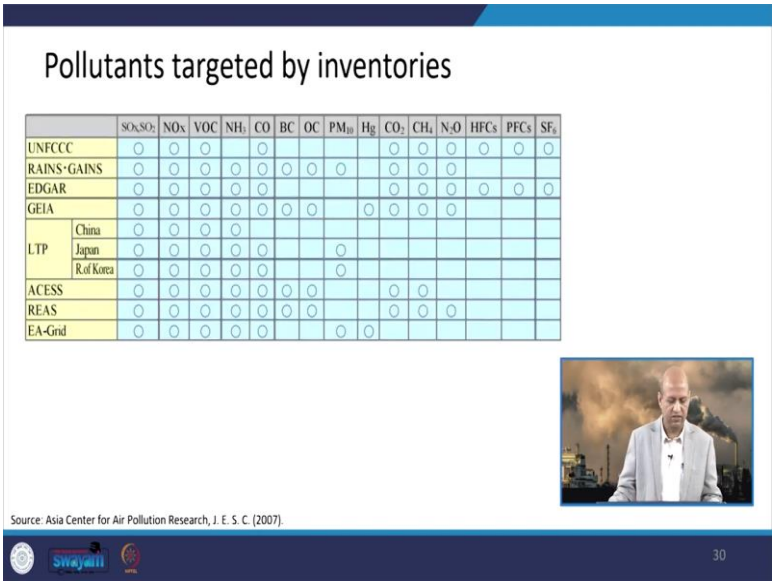

		SO_x,SO_2	NO_x	VOC	NH_3	CO	BC	OC	PM_{10}	Hg	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
UNFCCC		○	○	○		○					○	○	○	○	○	○
RAINS·GAINS		○	○	○	○	○	○	○	○		○	○	○			
EDGAR		○	○	○	○	○					○	○	○	○	○	○
GEIA		○	○	○	○	○	○	○		○	○	○	○			
LTP	China	○	○	○	○											
	Japan	○	○	○	○	○			○							
	R.of Korea	○	○	○	○	○			○							
ACESS		○	○	○	○	○	○	○			○	○				
REAS		○	○	○	○	○	○	○			○	○	○			
EA-Grid		○	○	○	○	○			○	○						

The pollutants targeted by different inventories are different you can see like UNFCC related like SOx, SO_2, NOx, we use these etc there, but ammonia is not considered in this. Black carbon, organic carbon, PM_{10}, Mercury is also not considered by this UNFCC. It has CO_2 methane and two etc. Rains-gains it has this black carbon organic carbon PM_{10}. So, you can see in this particular table and chart different emission inventories have different strengths in terms of particular pollutants.

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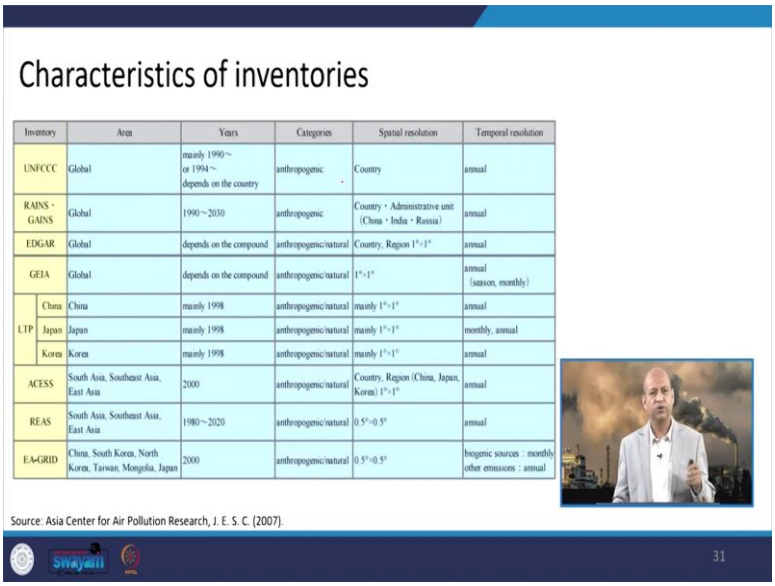

Inventory		Area	Years	Categories	Spatial resolution	Temporal resolution
UNFCCC		Global	mainly 1990~ or 1994~ depends on the country	anthropogenic	Country	annual
RAINS · GAINS		Global	1990~2030	anthropogenic	Country · Administrative unit (China · India · Russia)	annual
EDGAR		Global	depends on the compound	anthropogenic/natural	Country, Region 1°×1°	annual
GEIA		Global	depends on the compound	anthropogenic/natural	1°×1°	annual (season, monthly)
LTP	China	China	mainly 1998	anthropogenic/natural	mainly 1°×1°	annual
	Japan	Japan	mainly 1998	anthropogenic/natural	mainly 1°×1°	monthly, annual
	Korea	Korea	mainly 1998	anthropogenic/natural	mainly 1°×1°	annual
ACESS		South Asia, Southeast Asia, East Asia	2000	anthropogenic/natural	Country, Region (China, Japan, Korea) 1°×1°	annual
REAS		South Asia, Southeast Asia, East Asia	1980~2020	anthropogenic/natural	0.5°×0.5°	annual
EA-GRID		China, South Korea, North Korea, Taiwan, Mongolia, Japan	2000	anthropogenic/natural	0.5°×0.5°	biogenic sources : monthly other emissions : annual

Now, if we talk about characteristics of inventories, so, basically like how much area they are covering? So, UNFCC related, those emission inventories are global. So, for all countries they are providing emission values. Rains-gains is also global and then LTP like China,

Japan, Korea, so, they are country specific. And then access is covering South Asia that means, this India, Sri Lanka, Bhutan all those countries within the South Asia and Southeast Asia and East Asia these are the countries access inventory considering.

And what are the base years what are the categories anthropogenic or natural emissions are also being considered. Then the spatial resolution, the country wide or the 1° x 1° that that kind of thing is there. Then temporal resolution, whether it is annual or some seasonal those kind of things are there. So, you can see here every emission inventory has certain characteristics. So, accordingly the uses are also defined.

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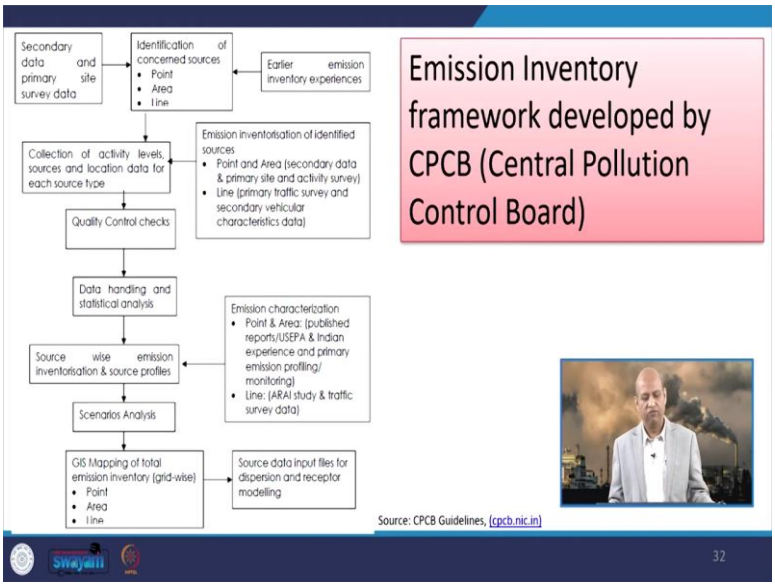

Well the emission inventory framework developed by CPCB, Central Pollution Control Board of India is given here. So, you can see like career emission inventory experiences based on those like identification of the consent sources those sources can be point source or the line source or the area source and then the secondary data and primary sites survey data which are available from secondary data may be available from the published literature or reports that is also available.

Then we collect all activity levels sources and location data for each source type. And then the emission this inventorisation of identified sources of as we discussed point, line, like that, then quality control check should be there, data handling and this statistical analysis must be there because uncertainty analysis is a very important component otherwise, maybe the estimations are we away from much away from the realistic values.

Then the source wise emission inventories and source profiles, scenario analysis different kinds of scenarios. Then we have this GIS mapping, the grid based emission inventory we can develop. So, this is the basic framework which has been recommended by central pollution control board. So, that different pollution control board or state pollution control boards and agencies, they can follow this particular framework.

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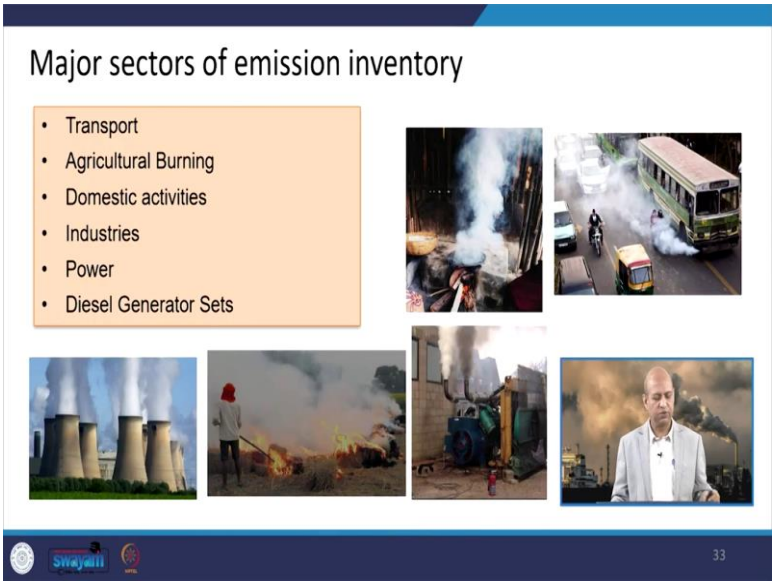

Then the, if you talk about major sectors of emission inventory. So, again this is just a kind of sample for transport, agriculture burning, domestic activities, industries power, digital generated, but you can also add like for construction activities or the waste burning, you can just add whatever activity you want to include in the emission inventory. So, these are just sample activities.

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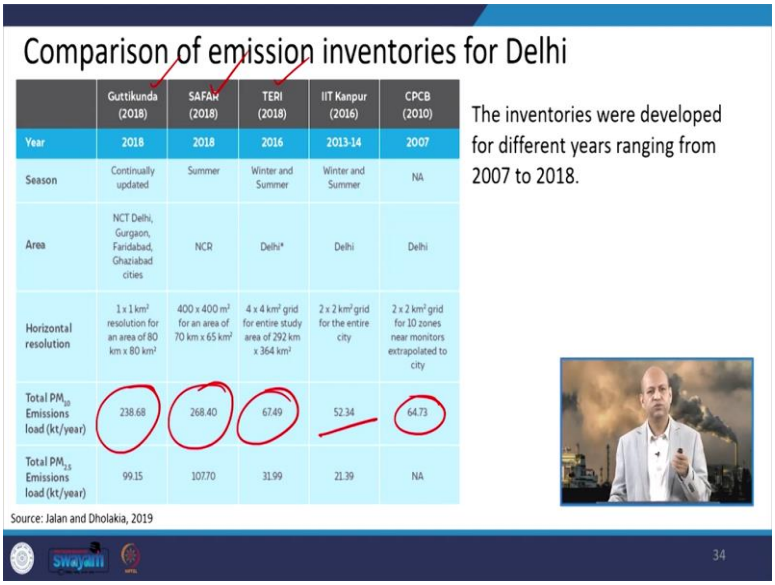

And accordingly those sectors we will discuss later on. When we compare emission inventories for Delhi then like seasonal or area which area is there, NCT Delhi, year of total PM_{10} then the Guttikunda, 2018, emission inventory, suffer emission inventory 2018, TERI develop 2018. So, these are three emission inventories you can see variation. PM_{10} like TERI rated only 67 the kiloton per year and this giving 238 and this is 268. So, they are near but there is a lot of difference here.

So, what kind of sources they have considered, we have to see. Then the total $PM_{2.5}$ emissions also it gives a different values and IIT Kanpur related values are 52.34 for PM_{10}, CPCB 2010 published this 2007 year fall, they have 64 this kiloton per year. So, accordingly because there are changes 1 x 1 kilometer or 400 x 400 meter square meter or 4 x 4 kilometer, 2 x 2 kilometer according to different kind of grid size, different kinds of activities, different kinds of emission factors, the values may differ for each inventory.

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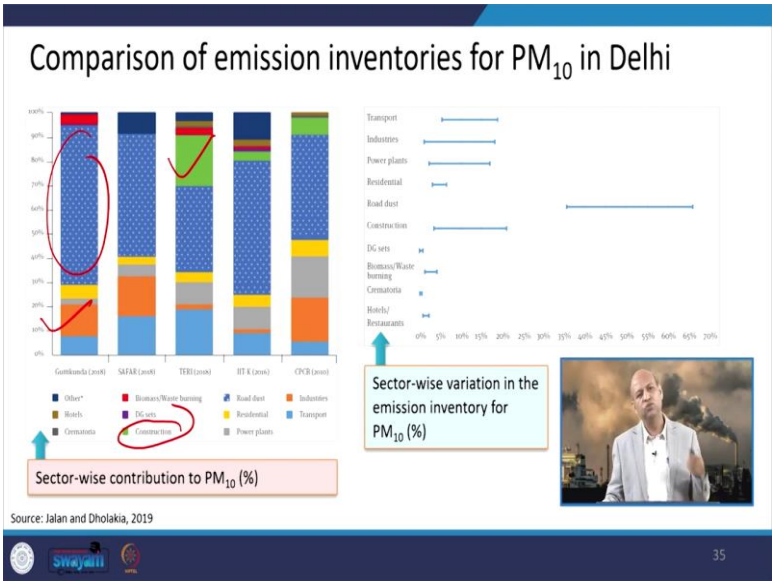

So, it is not necessary that one inventory is good and one other is bad, it depends on several factors which have been considered to develop the emission inventory. Well, when we talk about sector-wise contributions to PM_{10}. So, when we compare emission inventories for PM_{10} in Delhi, you can see here different values for different sectors are there like here these industries are up to this kind of percentage.

But for road dust is given much more for this inventory. And in TERI, it is not given so, much share rather in TERI in emission inventory, the construction activities having quite good share. So, maybe they have not considered that particular activity. So, we have to see which parameters they have considered for developing the emission inventory that is why the variation may be there.

Similarly, the estimated values also vary like sector wise variation in the emission inventory or PM_{10} you can see here, so, for transport, 5 percent to 20 percent variation can be there, and, like DG sets, it is quite less so, estimations are quite closure, but for road dust a lot of variation 35 percent to like 65 percent. So, it means a lot of uncertainties are there. So, we have to look into the methodology.

The methodology the emission factors they have used and the season and all the variation variable factors which are used for calculation purpose, then we will be able to know why this variation is there plus at the same time these kinds of variations also gives an indication that lot of uncertainties are there, and we have to reduce those uncertainties, so, that the variation reduces and we come to some kind of actual value.

But, this is a kind of dynamic process and every time some new changes are there, the new emission inventory we have to develop. So, we have to go for this way.

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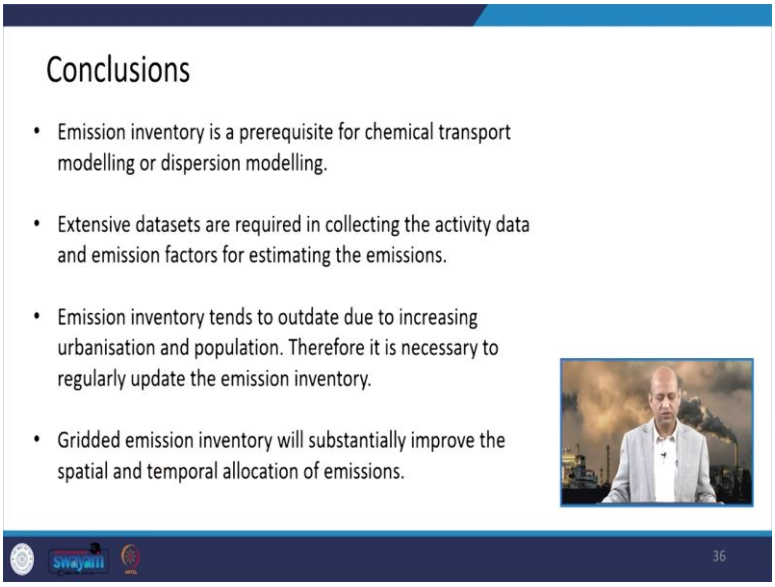

So, ultimately we can conclude that the emission inventory is a prerequisite for Chemical Transport modeling or dispersion modeling to calculate ambient air concentrations. And the extensive data sets are required in collecting the activity data and emission factors for estimating the emissions in this bottom up approach you can see. And the emission inventory always tends to outdate due to increasing urbanization or population.

Therefore, it is necessary to regularly update the emission inventory. Otherwise, if we are using the old emission inventory, and we are, estimating air quality concentrations by using those old emission inventories, then those moderate concentrations will not be as per the reality it will be erroneous kind of estimation. Then the gridded emission inventory will substantially improve the spatial and temporal allocation of emissions.

And that way the air quality models, dispersion models will also give better estimations for ambient air concentrations. So, this is all for today is an introduction to show you the importance of emission inventory. Now, next time, we will see what are the different sectors and how do we estimate the emission inventory for that particular sector. So, this is all for today.

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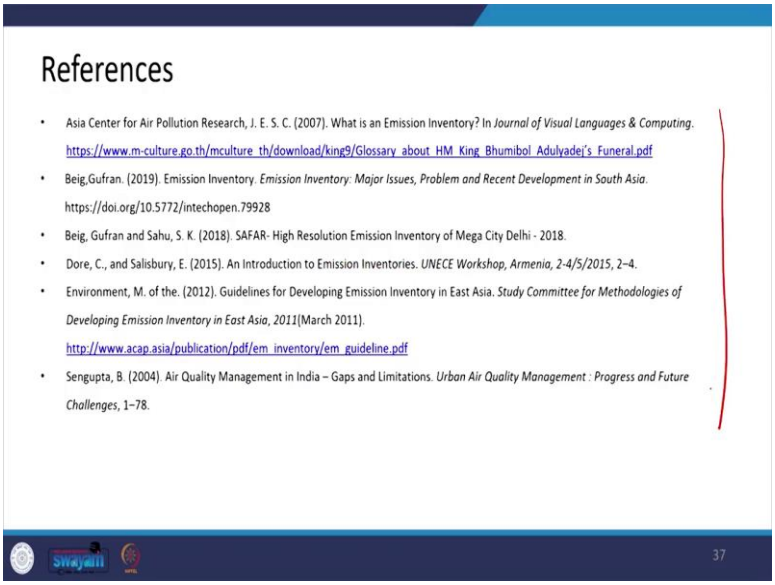

And the reference list is there for additional information. Thank you for your kind attention. See you again in the next lecture. Thanks again.