Sustainable Transportation Systems
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Lecture 58
Sustainability Indicators

Hello friends. As you know, we have discussed several aspects of transportation focused on sustainability of the transportation systems. So, whether the existing transportation systems, how can we make them more sustainable? Or how can we design some new transportation systems which are sustainable? And how to identify whether it is sustainable or not?

So, we have seen several kinds of aspects when we were discussing about impact assessment or life cycle assessment. So, today we will see those indicators, which really help us to know whether the system is sustainable or not. So, that means in a quantitative manner, we can judge whether a system or whether a part of the system is having sustainability aspects in positive or negative manner. So, today we will discuss.

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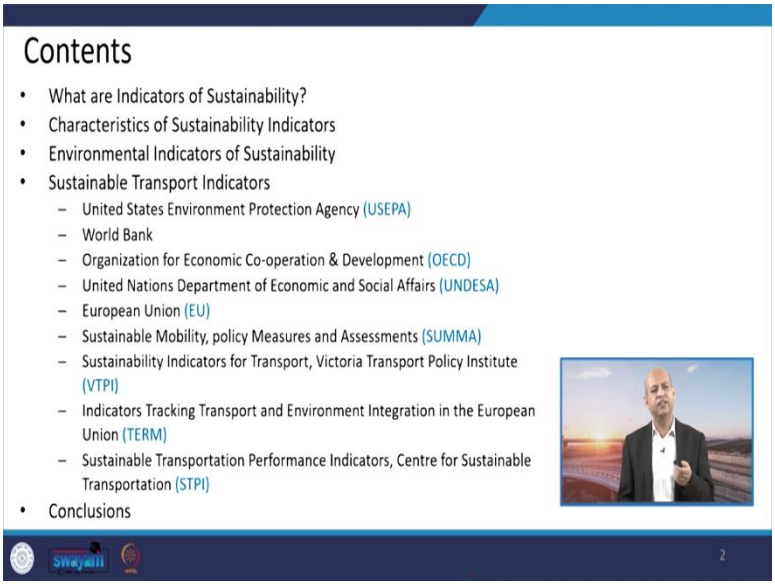

These are the contents, like what are the indicators of the sustainability and the characteristics of sustainability indicators? Because whenever we talk about indicators, there are certain features of the indicators, which help us to judge in terms of the sustainability aspects. Environmental indicators of sustainability, because indicators may be of a different nature, like social, economic, political, there are so, many things.

So, environmental indicators, we will focus upon. Then we will see the sustainable transport. The indicators are developed and propagated or proposed by several agencies like United States Environmental Protection Agency US EPA or the World Bank or Organization for Economic Cooperation and Development OECD, then United Nations Department of Economic and Social Affairs or European Union.

Then Sustainable Mobility, policy Measures and Assessments. This is a project which is run by EU and Sustainability Indicators for Transport, Victoria Transport Policy Institute related measures. Then Indicators Tracking transport and Environment Integration in the European Union. So, that is another way of looking at sustainability. Then Sustainable Transportation Performance Indicators, which is proposed by Centre for Sustainable Transportation. And at the last we will conclude.

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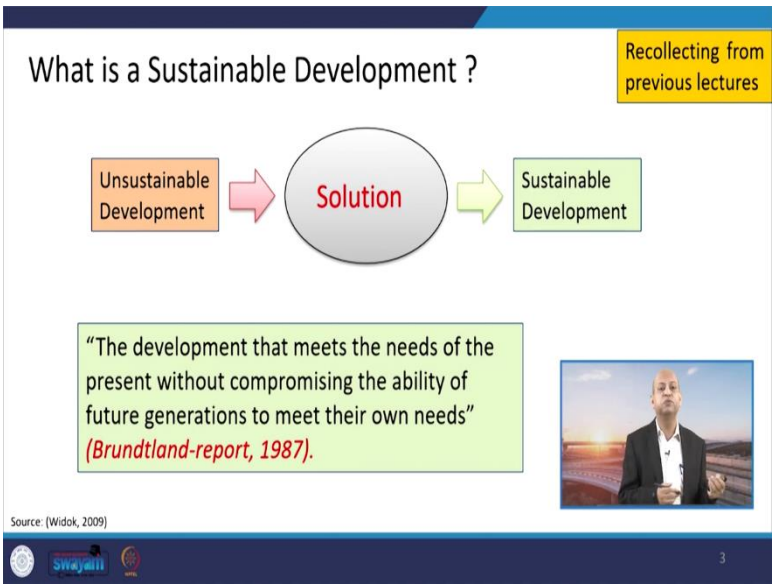

So let us revise a few things which are basics or fundamentals of the sustainable development or sustainable transportation. So, these are the things which you have already seen, but let us revise it so, that we can make a basis to go further. Well, when we talk about sustainable development, what is the sustainable development? And as you know, there are many definitions.

And the most popular definition, which was known as the based on this Brundtland-report in 1987. It was proposed that the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. But it is debatable, as I said earlier, there are new definitions, but basically whatever sustainable development we want to achieve, we have to solve those problems, which are making it unsustainable.

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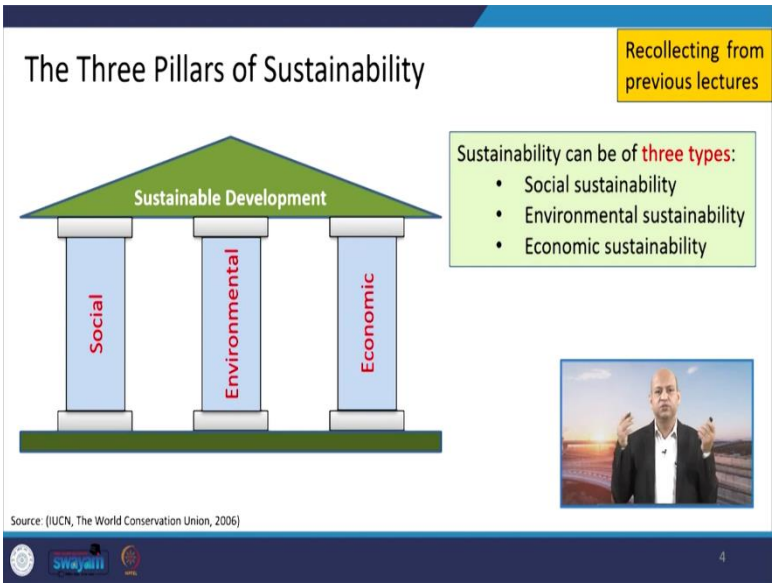

Then we talk about, on which basis we are going towards sustainability development related direction. So, we talk about these three pillars of the sustainability. These are social, environmental, and economic. So, the social sustainability, environmental sustainability and economic sustainability. So, integration of these three pillars, we have to see otherwise in one way it can be sustainable, but in another way it maybe unsustainable. So, that is not in total sustainable.

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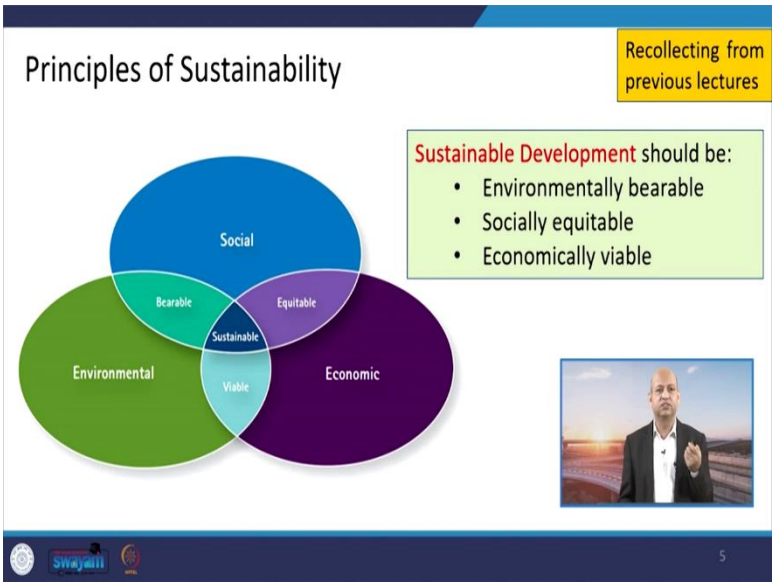

Then we, when we talk about principles of sustainability. So, again, we try to encompass all those three pillars, so, social and environmental and economic aspect. So, we have to see that this particular project or whatever technology we are trying to implement. So, that is environmentally bearable and socially equitable and economically viable. So, those kinds of aspects we have to see to see to ensure that the sustainability related aspects are met properly.

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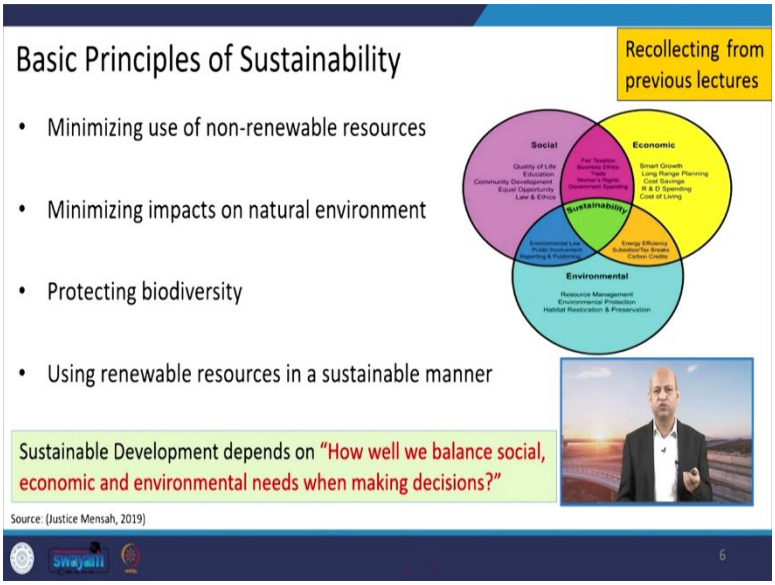

Then again, when we talk about basic principles of sustainability, then we try to minimize the use of non-renewable resources, because using the non-renewable resources are basically the carbon-based economic model, which is making many things unsustainable because of air pollution, climate change, and there are many other issues. Then we also see that minimizing impacts on natural environment.

Otherwise, there are some carrying capacities or balance of ecosystems, which is disturbed then, which create some negative externalities and we bear the brunt of that particular activity. Then we need to protect the biodiversity. So, these are, again, basic principles of sustainability.

We also want to enhance the renewable resources uses is in sustainable manner. So, you can see that the sustainable development depends on how well we can balance the social, economic and environmental needs when we are making decisions regarding any kind of anthropogenic project, or activity.

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Well then sustainable development goals or SDGs which are from United Nations. So, again, they also talk about various aspects of human life. So, you can see like no poverty or zero hunger or good health. So, in that can also have better transport infrastructure, better accessibility. All these things are there. So, sustainable development goals are basically related to all kinds of activities, which influence our quality of life.

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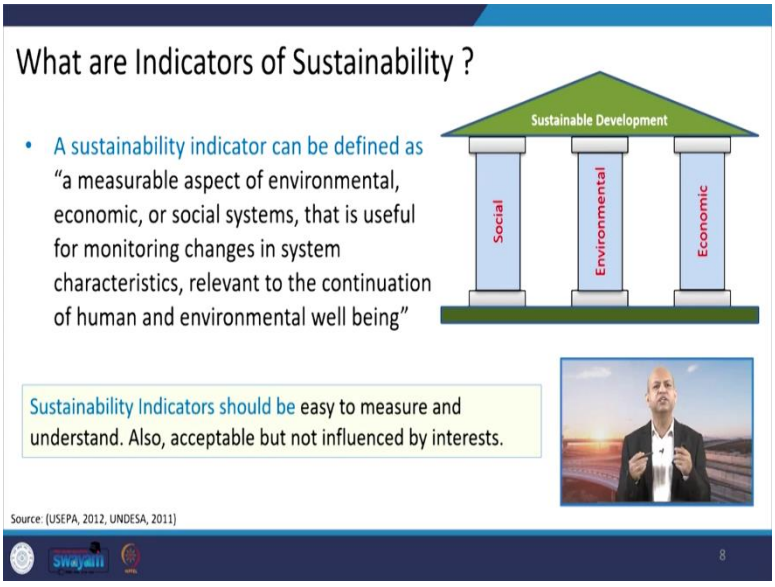

Then again, when we talk about the indicators of sustainability, so, mainly we focus on these three aspects like social, environmental, and economic, and we will talk about these aspects in different manner, but their integration is very important when we achieve, we want to achieve the sustainable development.

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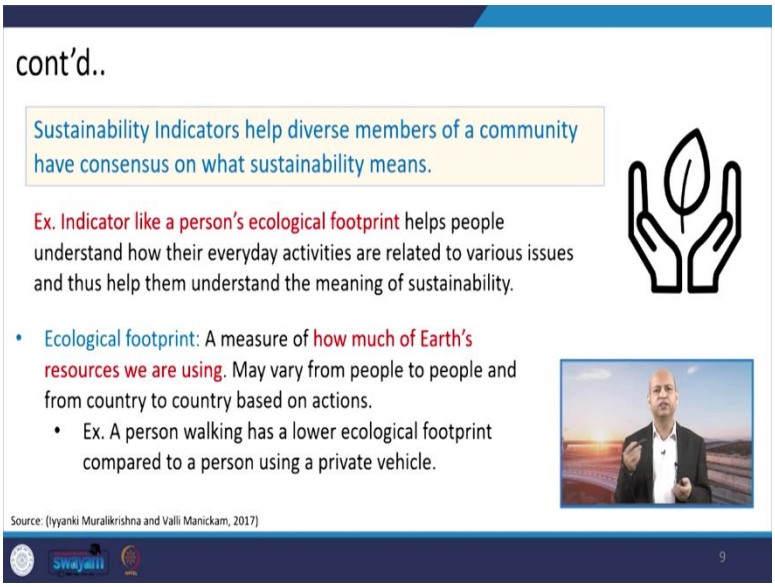

Well, the indicators, the nature of the indicators also depends, for example, indicators or person's ecological footprints, it can help us to understand whether we are making negative impacts or positive impacts. Like we also talk about carbon footprints, for example, I want to travel from here to Delhi. So, whether I take some public transportation or I take a car, or I take this air journey.

So, all these three different kinds of, transportation mode will have different carbon footprints. So, those, transportation modes, which contribute a lot of greenhouse gas emissions or air pollution. So, that is not good. That is not in a sustainable we way of doing things. So, ecological footprint is also in that terms. We can have some aspect of the ecology and we can see whether the impact is positive or negative.

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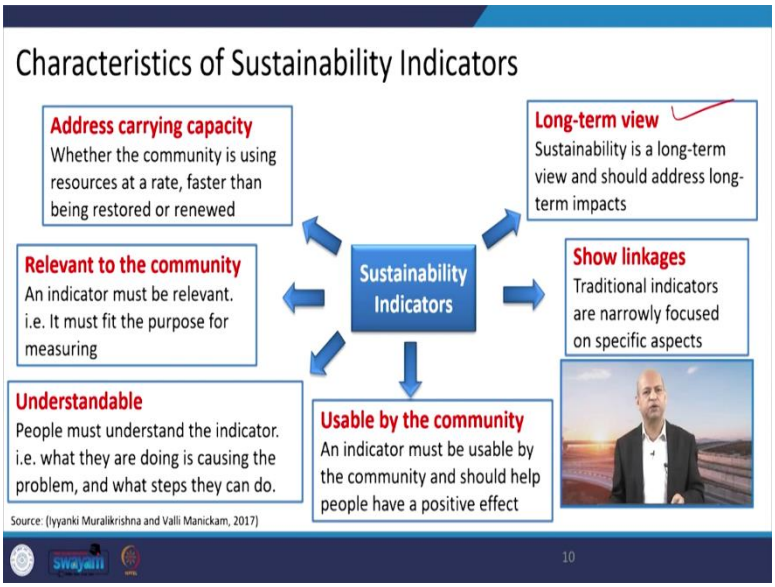

Similarly, when we talk about different characteristics of sustainability indicators, then we help to see like a long-term view because sort term, focus is not good for making things sustainable. So, the sustainability is a very long-term view and it should address long-term impacts not only the short-term, but long-term impacts. Then it also should have the linkages like traditional indicators are narrowly focused on specific aspects.

But the linkages can be on general aspects also. It should be usable by the community. It should not be very complex. It should be simple. So, that layman can also understand and see whether something is sustainable or not. For example, nowadays ACs or these freeze and many gadgets are coming with some stars or energy usage related things. So, very simple things, even air pollution, air quality indicators are there in colours red or yellow, green, those kinds of things.

So, that everyone can appreciate whether the air quality is good or bad. Then it should be understandable. So, that is why this kind of iconic, activities or colour schemes, all these indices can really help the people to understand those indicators. Then the relevance with the community. Because, if you want to have some kind of sustainability indicators in rural areas, there will not be like urban areas because the population segment is different.

Their economic level, their education level is different. So, according to the community, the indicators must be in different manners. It should also address the carrying capacity like, when we are using some resources at a particular rate. So, it should not deplete in very fast. We should be addressing those aspects also.

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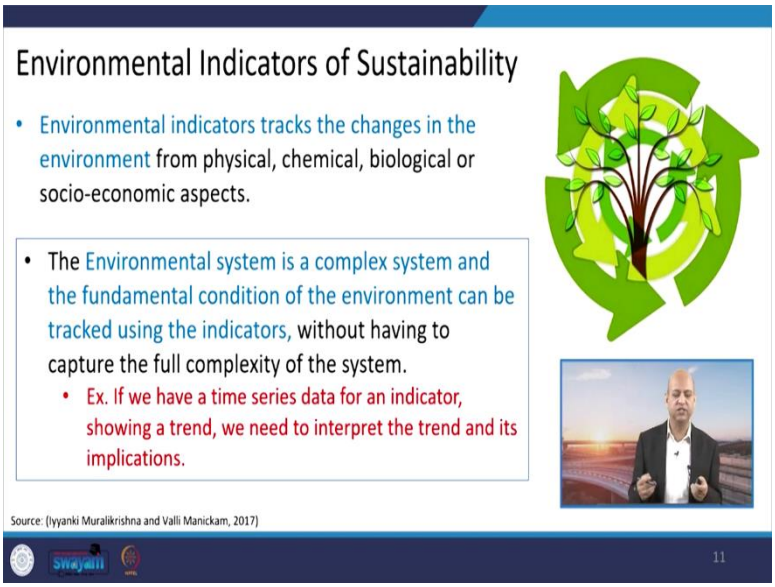

Otherwise, for example, urban air shade is there. So, we should not have so much emissions that air pollution levels become so high that the air quality exceeds the permissible limits. So, that is not good. So, that will be exceeding the carrying capacity. Those are those kinds of aspects. When we talk about environmental indicators, then we talk about air, water, soil their quality, physical, chemical, biological, all, and socio-economic aspects.

But the environmental aspect is the central one. And, it is a complex, but we have to make it simple in terms of indices, air quality indices, water quality indices, those kinds of things. So, that we can understand and implement it properly.

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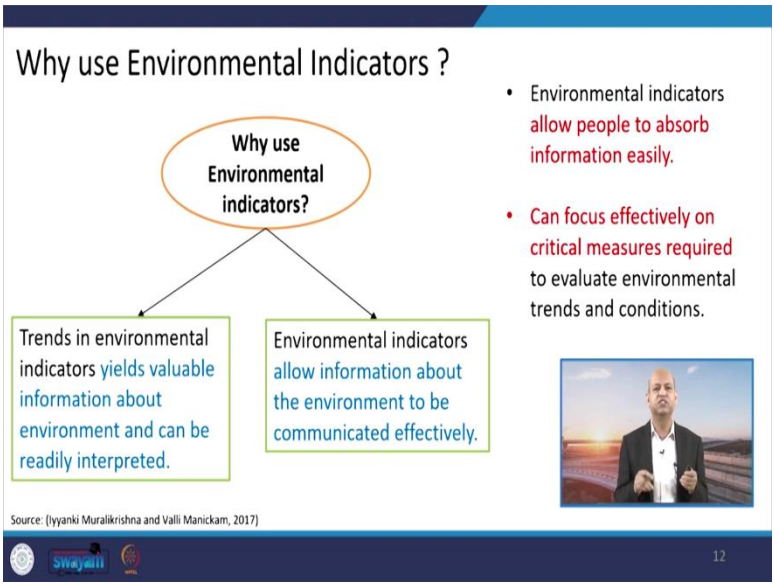

Why we use environmental indicators? Because it allows people to absorb the information easily. As I said, some colour scheme, some tabular form, some scoring, all those things are easy to understand. Otherwise, everyone is not going to read the scientific papers and to know nitty-gritty of these things. So, we have to make them very simple, and it can also focus effectively on critical measures required to evaluate environmental trends and conditions.

Because when you have to compare like air quality of different cities or air quality of different seasons, so, these indicators help us to compare and make decisions very easily and very quickly, otherwise you have to go through several complex reports and complex calculations, which are the part of, engineers or scientists, but for lay men, for policymakers, the indicators are the real, basis when the decisions are made.

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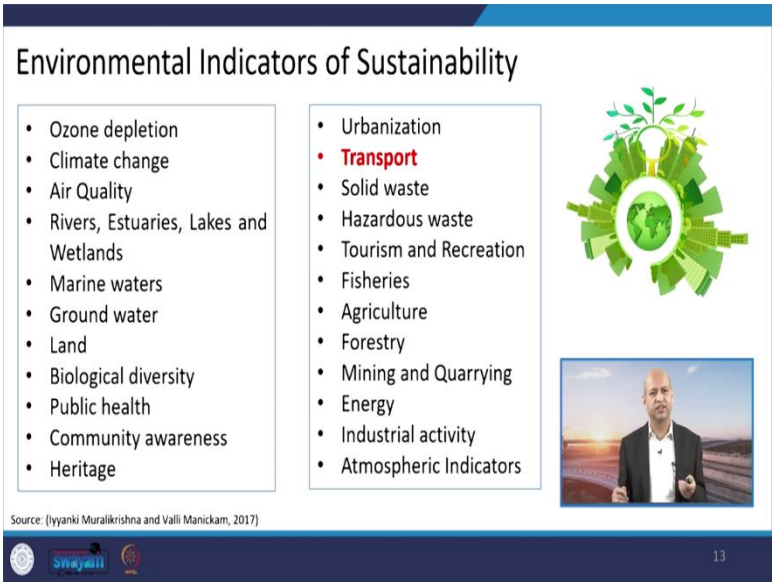

Well, when we talk about these environmental indicators of the sustainability, then we talk about several of its features or aspects like ozone depletion or climate change, air quality, groundwater quality, land usage, agriculture, transport, solid waste management, everything. All these things which affect one or other kind of aspect of the environment we have to consider them.

So, the transport is also very important. You can see, and this course is about sustainable transportation system. So, our focus will be more on transport. Otherwise, there may be several indicators, several environmental indicators.

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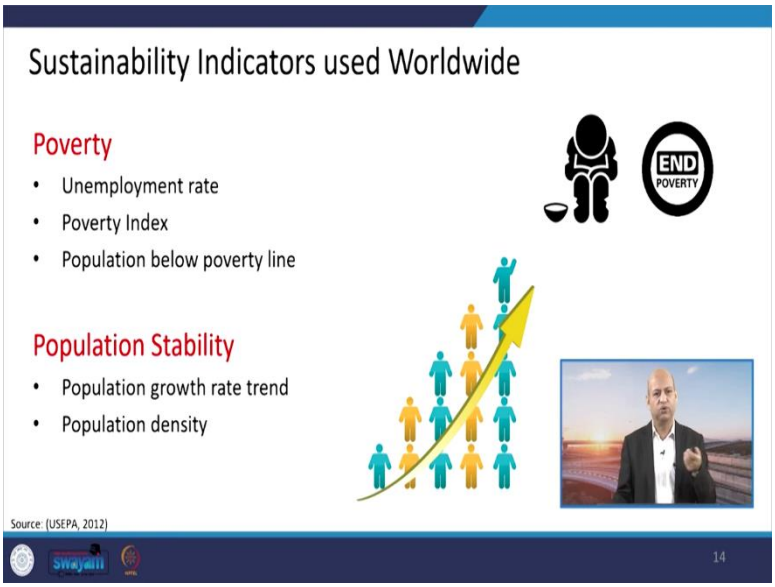

And the sustainability indicators, which are used worldwide of different nature. Like if, if you talk about poverty, then we have to see the unemployment rate. We have to see the poverty index or population below poverty line, those kinds of things we have to see because several policies are based on those figures. So, these kinds of indicators also help us to implement those policies.

Similarly, if you want to see the population stability, then we need to see the population density of a particular area or the country than population growth rate trend. Because, sometimes, because of our lifestyle population decreases like in developed countries, population is decreasing. But to support the complete ecosystem of the society, we need to have certain rate of the population growth. So, all of these things are helpful in understanding those things.

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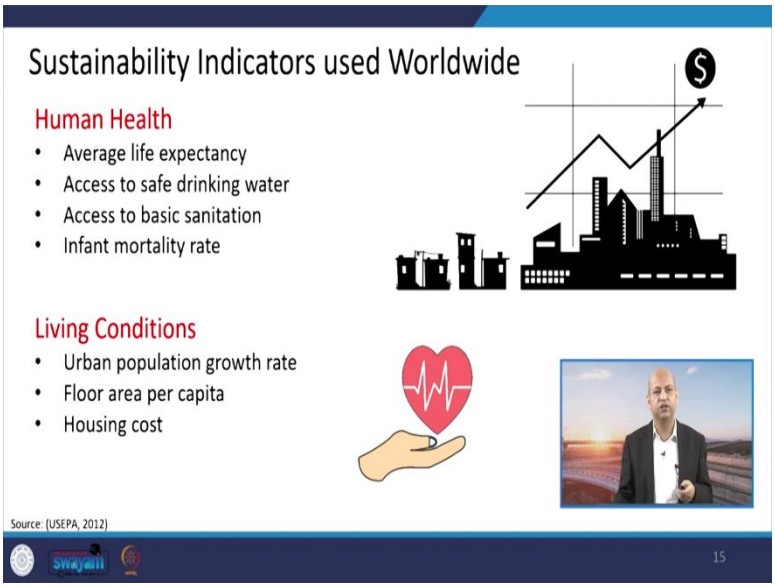

When we talk about like human health, then the average life expectancy, and then the safe drinking water, air quality or basic sanitation related things or infant mortality rate, all these are the indicators which help us to understand the human health related aspects of a society. Then living conditions. So, population growth rate in a city or floor area per capita housing cost, etc., are the part.

For example, I remember when I was doing post-doc in Germany, I got to know that in, for a family, if you want to go renting a house, then there are certain rules and regulations. You cannot live in a small place. There are certain space or area, which is compulsory for the quality of life. So, how many members are there in your family? So, accordingly the floor area should be ensured for better living. Otherwise, it is not a good way or a sustainable life you can say.

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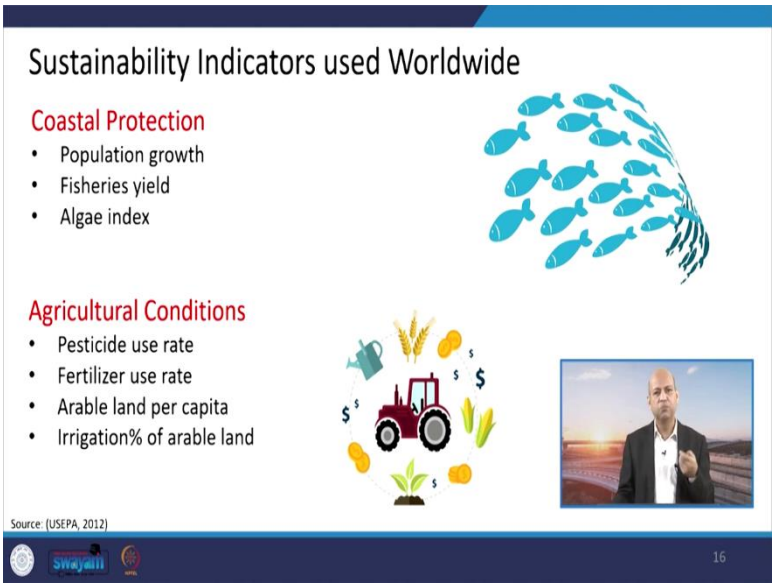

Then we talk about like coastal protection. Then again, like fisheries, how much it is coming or pollution of the these, those coastal areas or algae index, all those, because they also help in population of the fishes. And then if you talk about agricultural conditions, then you talk about like how much pesticides people are using farmers are using, because that will influence the quality of the soil and other related things.

Then fertilizer use rate, or arable land per capita, irrigation percent of arable land. Those things are there for agricultural conditions. As you know, because of the wrong agriculture practices in several parts of India, groundwater has gone very deep. So, all of these things we have to see, these are the part of the agriculture conditions and those can be the indicators.

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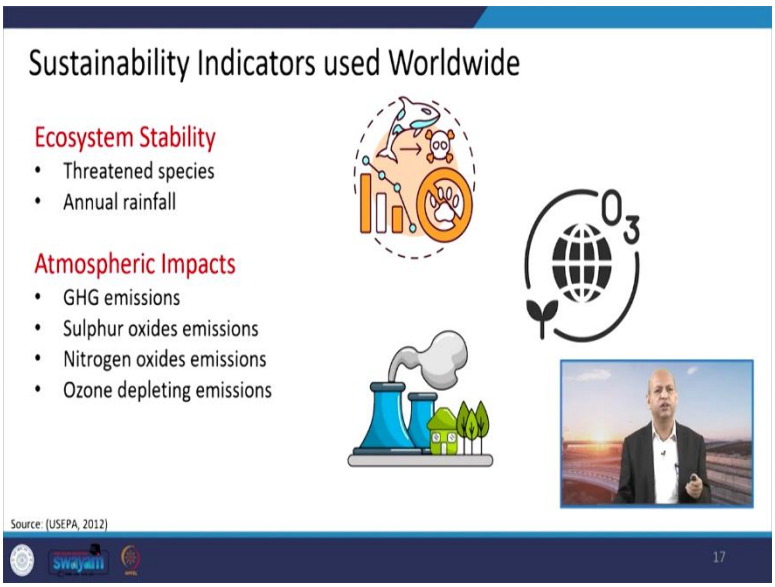

When we talk about like ecosystem stability, then again, some species may be there, which are endangered. So, we have to see their numbers, their population, annual rainfall, or if you want to see the atmospheric impacts then we have to see how much emissions are there of air pollution or greenhouse gas emissions or oxides of the sulphur or oxides of nitrogen or particulate matter. Then ozone-depleting emissions are there. So, all these related to air quality, we have to see if you want to study the atmospheric impacts.

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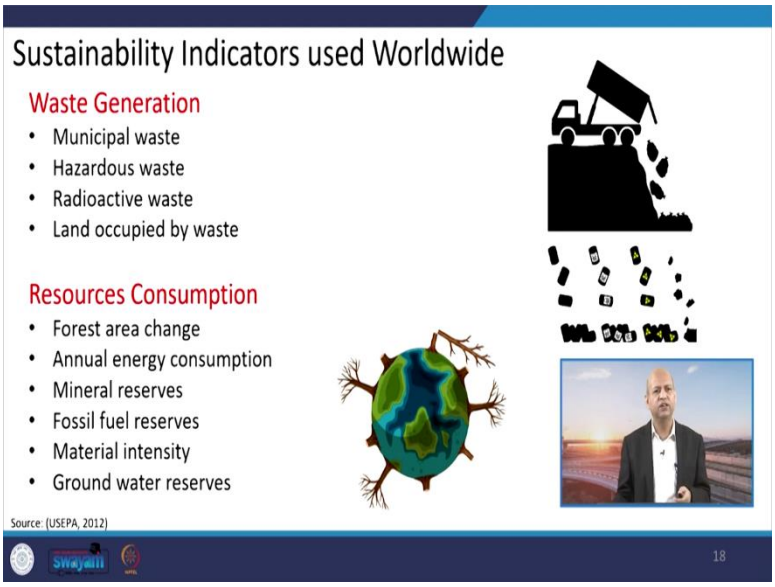

Then we talk about waste generation. Then we need to look at municipal waste. How much generation is there? Hazardous waste is there or not? radioactive waste we have to segregate them, land occupied by the waste or when we talk about consumption of the resources, then we have to see like fossil fuel reserves, how much material intensity or mineral reserves, forestry, all those things are part of those resources' consumption.

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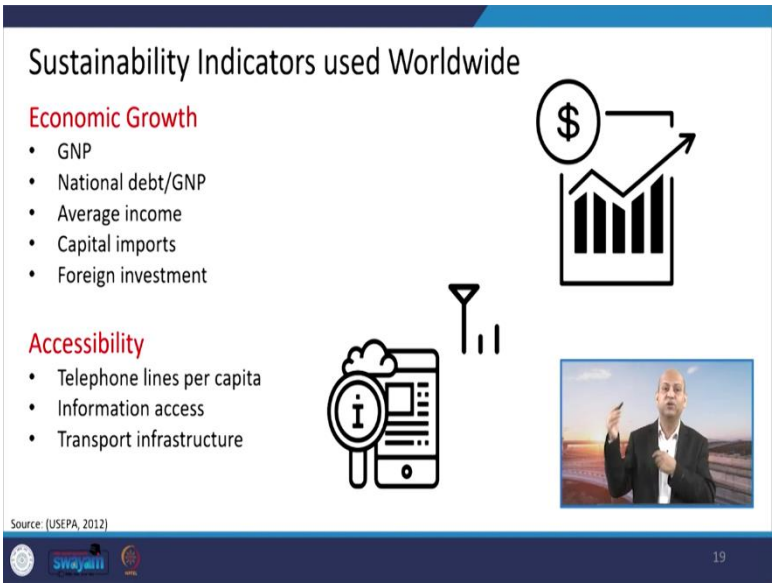

When we talk about like economic growth, then GDP and GNP or national debt or average income per capita income, all these are the parts of economic growth-related indicators. When we talk about the accessibility. So, the infrastructure accessibility, accessibility to the schools, education, or other facilities like telephone lines or information access, all those, otherwise there is a divide.

For example, nowadays, you might be hearing that there is a great divide between urban education system and rural. In during corona period, urban people could access the education through online means, but the rural population could not access because there is no net facility of that intensity. So, all these are the issues.

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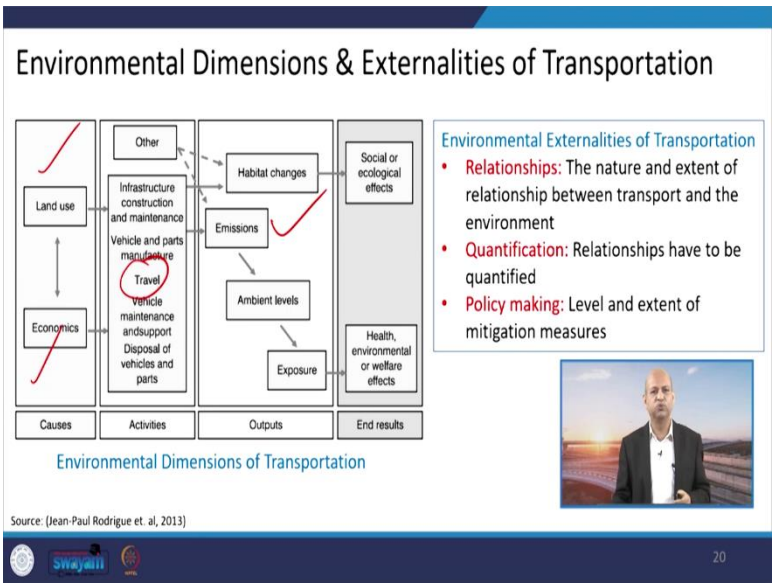

When we talk about like environmental dimensions and the external factors of the transportation, then you have to see all these integrated like land use, then economics of things. So, land use have all those travel-related things, infrastructure, road quality and then you can have the emissions related to the transportation. Then ambient levels of those air pollution exposure, which will have some health impacts.

So, the relationships of all these natural aspects and extent of the relationship with the receptor, receptors are those which are inhaling, polluted air, all those kinds of. Then quantification, because we have to establish if we want to see environmental impact assessment or risk assessment, so, we have to quantify. So, that relationship also very important. Then if you want to make a policy to reduce the adverse health effects, so, we need to have some sort of calculations, their levels and the impact of those air pollution levels on the health parameters.

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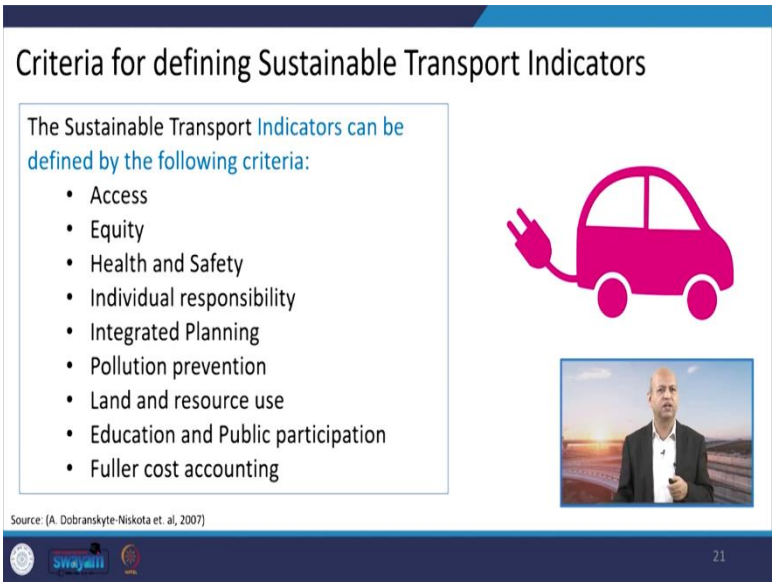

Well, when we talk about criteria for defining sustainable transport indicators, then we need to see whether the transportation infrastructure of the system is properly accessible or not. Maybe some population, some segment of the population like upper middle class is having access to a particular transportation system. And if it is not accessible by poor segment, then it is not sustainable socially.

It is not equitable kind of thing. Similarly, like health and safety issues because you have to have good road infrastructure, then traffic lights, etc., otherwise accidents may happen. Integrated planning, because if you are traveling from one place to another and you have to wait four hours to get another bus also, that is not a good thing. So, the integration of different transport modes is also necessary.

Last mile connectivity is also important. We have discussed all these issues, as you can remember. Then education and public participation, or the cost accounting in those infrastructure related to the transport we have to look into.

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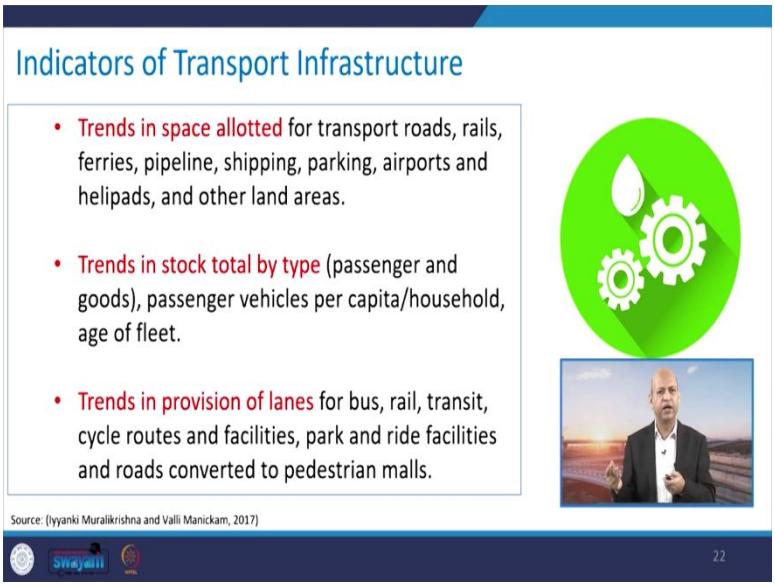

When we see the indicators of transport infrastructure, then we have to see like trends in the space allotted. So, how much space is being occupied by roads or rails or airports, etc. Similarly, the trends in stock of the total types like passengers or freight corridors or goods. Trends in provisions of the lanes related to bus or foot paths or cycle lanes, bike lanes, etc., all these things are part of that.

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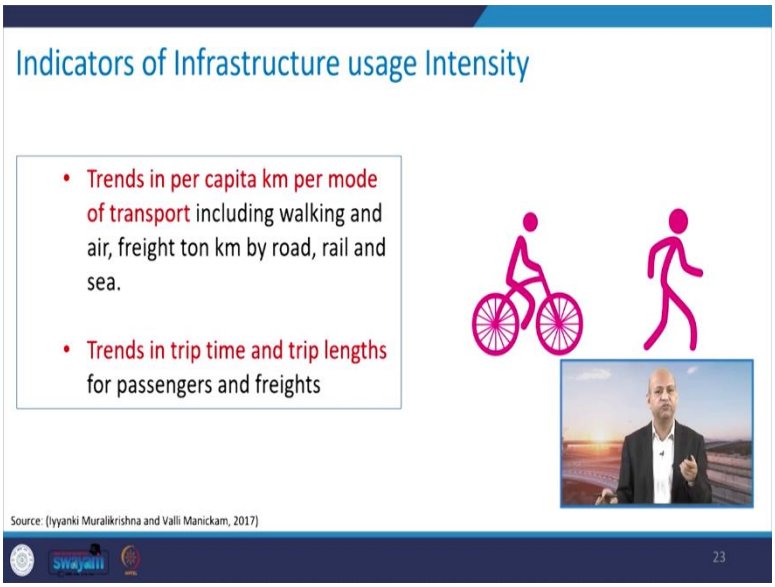

Similarly, like trends in per capita kilometre, per mode of the transport, how much they are traveling through bicycle or public transportation or walking; all these things we need to have. Similarly, trends in the trip time, or trip length, all these related to the freights or the passengers that values we have to see.

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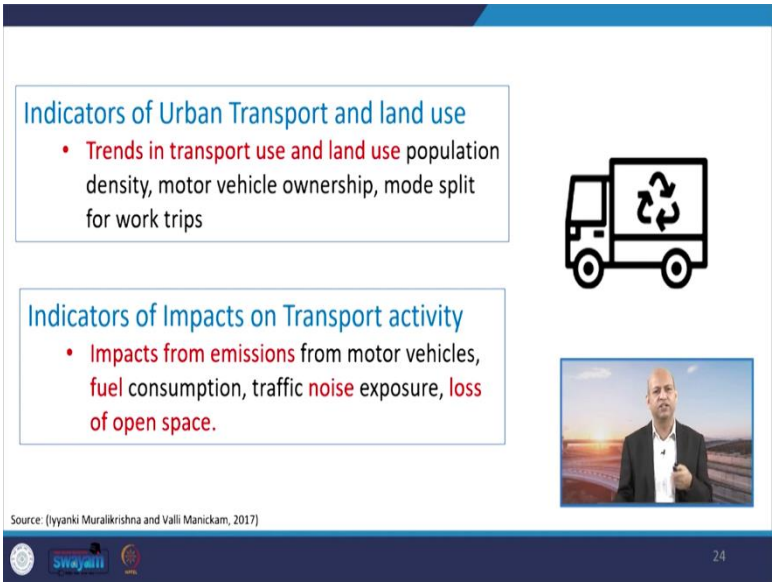

Similarly, when we talk about urban transport and land use, then we have to see the trends in transport use and land use. Population density, motor vehicle ownership, mode split or the work trips, etc. Because, in different cities, different kinds of population of this traffic or transport means are there. Like in big cities, people are having one or two means of the transport.

They might be having two cars or a two-wheeler then all those kinds of they add into the traffic density. Similarly, we help to see the impacts from emissions from the motor vehicle. So, whether two-wheeler emissions from the cars, four wheelers, public transportation, then the noise, loss of open space.

All these are the basic part of the quality of life, because you may have a transportation system, which is very much congestion oriented, then that is not good because it will waste a lot of time, as well as it will also add into pollution. Because of congestion, a lot of fuel will be burnt and the speed will be slow.

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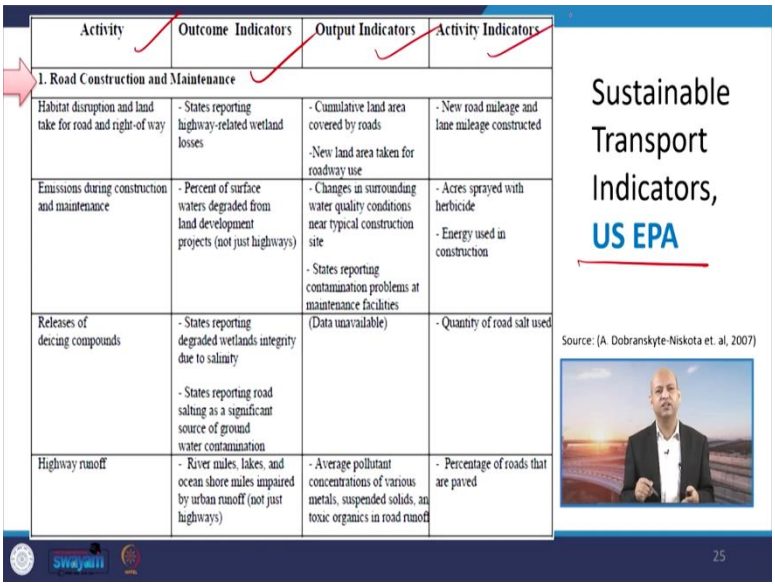

Well, similarly, when we talk about like these indicators, which are related to sustainable transport, so, they are being proposed by several agencies. Like US EPA, if you see, so, you can see like road construction and maintenance related things are there. You can see in this tabular form different metrics are there. Activity, outcome indicators, output indicators, activity indicators, all these are in detail. So, we have to have all those values and scoring related to those.

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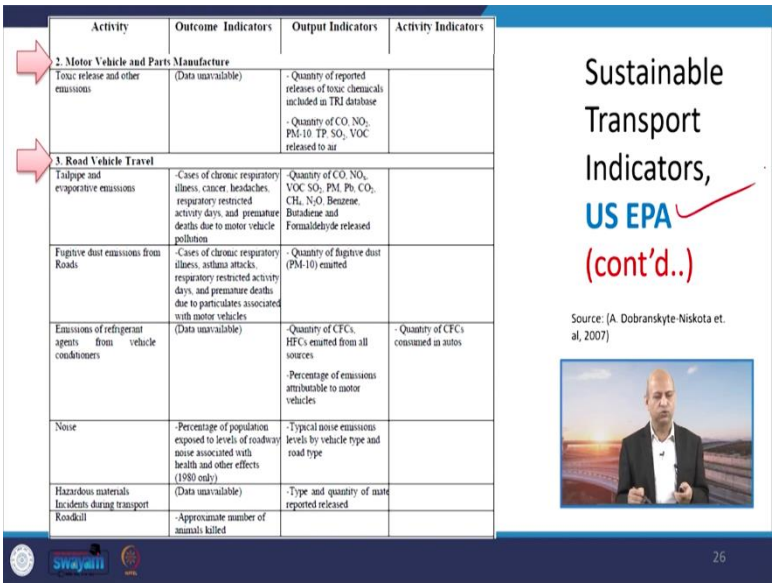

So, these are the indicators which are developed or proposed by different agencies. So, I can quickly pass through them like this is related to US EPA.

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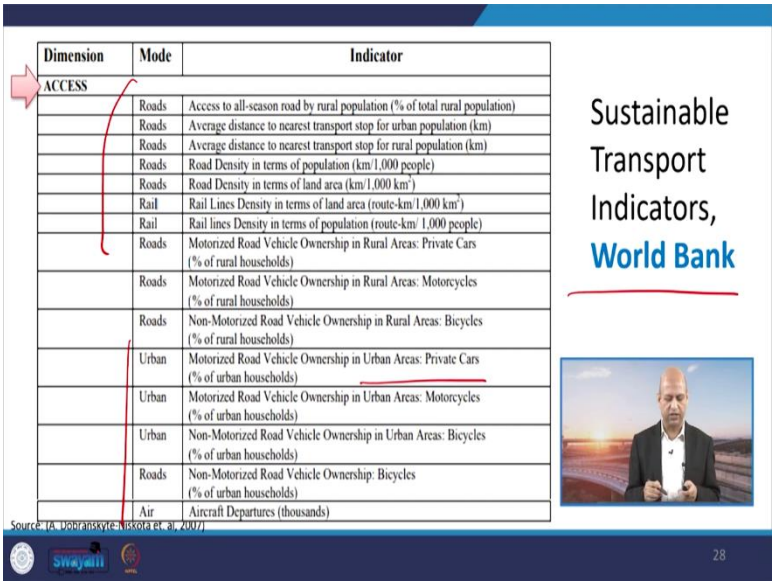

Then we can come to this World Bank related, sustainable transport indicators. So, they focus on more on roads then urban related like how much ownership in the urban areas are there private cars or public transportation systems, something like that. So, in fact, more or less all things are catered by every agency, but in different fashion, some, some agency give emphasis on a particular type of transportation mode or the aspect others may give emphasis too on different kind.

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AFFORDABILITY		
	Road	Motor Vehicle Fuel Prices: Gasoline (Super/ Regular) (US$/ liter)
	Road	Motor Vehicle Fuel Prices: Gas/ Diesel Oil (US$/ liter)
	Urban	Spending on Transport Services by Urban Households (% of Urban Household Expenditure)
	Rural	Spending on Transport Services by Rural Households (% of Rural Household Expenditure)
	Rail	Average Rail Tariff, Passenger (US$/ passenger-km)
	Rail	Average Rail Tariff, Freight (US$/ tonne-km)
	Roads	Road User Charges as Share of Total Road Expenditure (%)
	Ports	Port Handling Costs: containers (US $/TEU)
	Ports	Port Handling Costs: containers (US$/ ton)
QUALITY (*Technical Dimension*)		
	Roads	Paved Roads (% of Total Road Network)
	Roads	Roads in Fair/Good Condition (% of Total Road Network)
	Rail	Rail Traffic Density (traffic units/ km)
	Rail	Route Length of Multi-tracked Rail Lines (% of total rout-km)
	Rail	Rail Service Frequency (passenger train-km/ route-km)
	Roads	Fatalities in Road Motor Vehicle Accidents in terms of vehicles (Fatalities/ 10,000 vehicles)
	Roads	Fatalities in Road Motor Vehicle Accidents in terms of population (Fatalities/ 10,000 people)
	Urban	Urban Transport Modes (% of work trips)
	Ports	Seaport Traffic: containers
	Ports	Seaport Traffic: general cargo
	Rail	Rail Share of Passenger Domestic Travel (%)
	Road	Road Share of Passenger Domestic Travel (%)
	Water	Inland and Coastal Shipping Share of Passenger Domestic Travel (%)
	Air	Air Share of Passenger Domestic Travel (%)
	Rail	Rail Share of Total Freight Domestic Carriage (%)
	Road	Road Share of Total Freight Domestic Carriage (%)
	Water	Inland and Coastal Shipping Share of Total Freight Domestic Carriage (%)
	Air	Air Share of Total Freight Domestic Carriage (%)

So, we will see the comparison later on. But you can see like affordability or the quality. So, all these things, you have to have this kind of checklist or the metrics, which can give you the values. And ultimately, we can have some information which will help us to make the decisions.

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QUALITY (*Perception*)		
	All	Average Total Time Travelling by Rural Households (minutes/ days)
	All	Average Total Time Travelling by Urban Households (minutes/ days)
	Urban	Travel Time to Work in Main Cities (minutes/ one-way work trip)
	Roads	Commercial Perception of Services Delivered by Road Department/ Public Works
	Rail	Commercial Perception of Railway Services
	Air	Commercial Perception of Air Transport Services
	Ports	Commercial Perception of Port Facilities and Inland Waterways
	Ports	Cargo Handling Services: Market Openness
EFFICIENCY (*COST*)		
	Ports	Shipping Costs (ratio)
	Rail	Railway Employee Productivity (Annual Output/ Employee)
EFFICIENCY (*Economic*)		
	Roads	Road Transport System Technical Efficiency (US$/km)
FISCAL COST		
	Roads	Road Expenditure as share of GDP (%)
	Roads	External Funds as Share of Total Road Expenditure (%)
	Roads	Actual to Required Road Maintenance Expenditure (%)
FINANCIAL AUTONOMY		
	Roads	Expenditure on Owning and Operating Vehicles (US$)
INSTITUTIONAL DEVELOPMENT		
	Roads	National Roads Boards (NRB) Exists and Reports (at least annually) (Y/N)
	Roads	Private Sector Representatives from majority of NRB (Y/N)
	Roads	Main (National) Road Agency operating with Annual Report published (Y/N)
	Roads	Main (National) Road Agency publishing Technical and Financial Audits (Y/N)
	Roads	National Road Safety Action Plan (Y/N)
	Roads	Social Assessment of Road Projects Mainstreamed (Y/N)
	All	Gender assessment (Y/N)
	All	Access for all (Y/N)
	All	Planning (Y/N)
	Roads	Environmental Assessment of Road Projects Mainstreamed (Y/N)
	Roads	Communicable disease control (Y/N)
	All	Competitive Private Sector Participation in Transport Services (Y/N)
	All	Core labour standards (Y/N)
	All	Health and safety (Y/N)

Efficiency, or the fiscal cost. All these things are part of the world bank related sustainable transport indicators. When they want to fund some transit oriented development or Metro or big transportation or express ways or highways, then they have to judge or assess that particular project based on these indicators.

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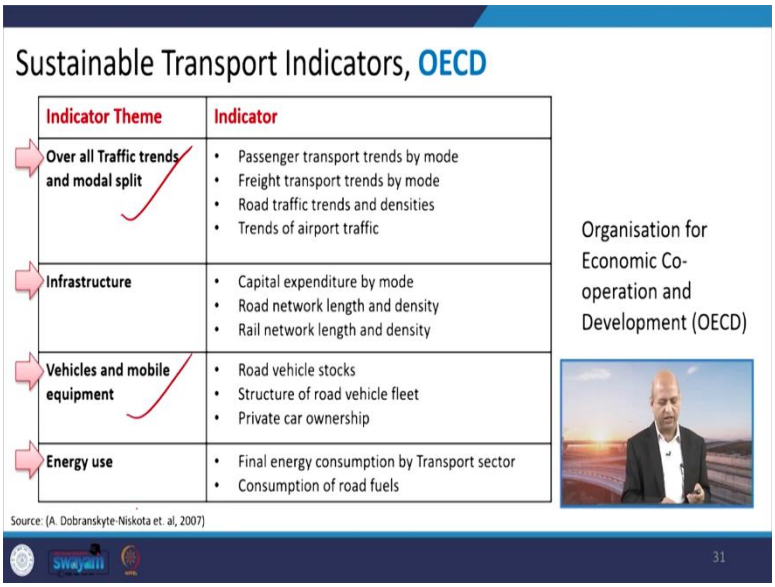

Similarly, the indicators of their sustainable transport is proposed by OECD, Organization of Economic Cooperation and Development. So, they focus on mainly for like overall traffic trends. And the model is split between different modes of the transport infrastructure related issues, road network, rail network, etc. Then vehicles and mobile equipments or energy use all these are there.

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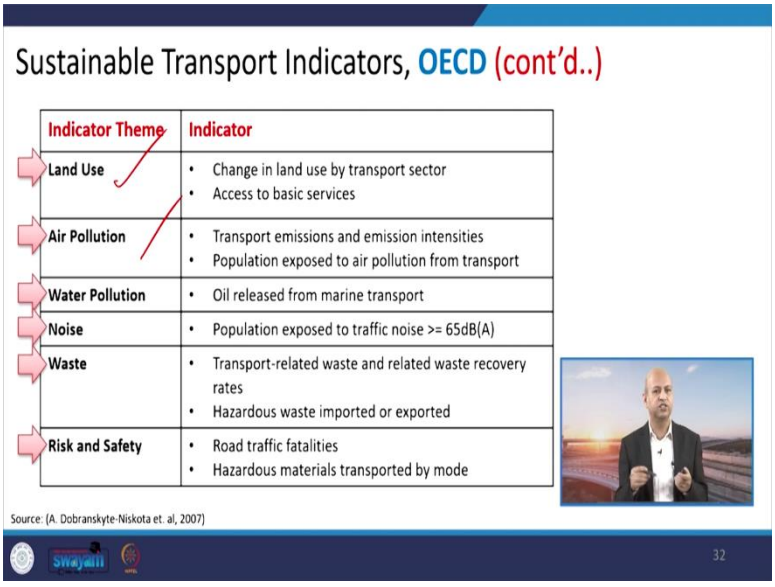

Similarly, like land use air pollution, water pollution, noise, waste, and risk and safety. So, these are the more important issues from OECD point of view.

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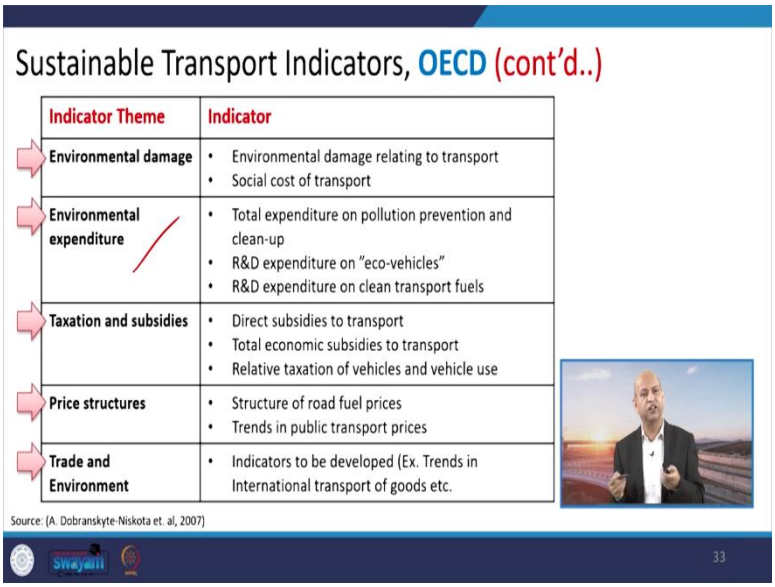

Similarly, environmental damage, environmental expenditure, taxation subsidies to promote the transportation, infrastructure, price structures, trade and environment, all these things are there.

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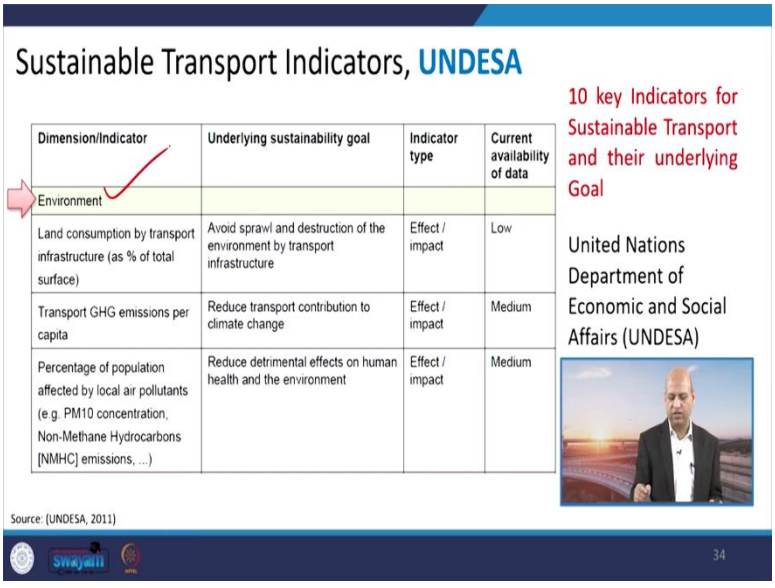

And when we talk about this UNDESA indicators, United Nations Development of Economic and Social Affairs, they have also proposed sustainable transport indicators. So, they are basically on environment so, they have given a different kind of values. 10 indicators are there.

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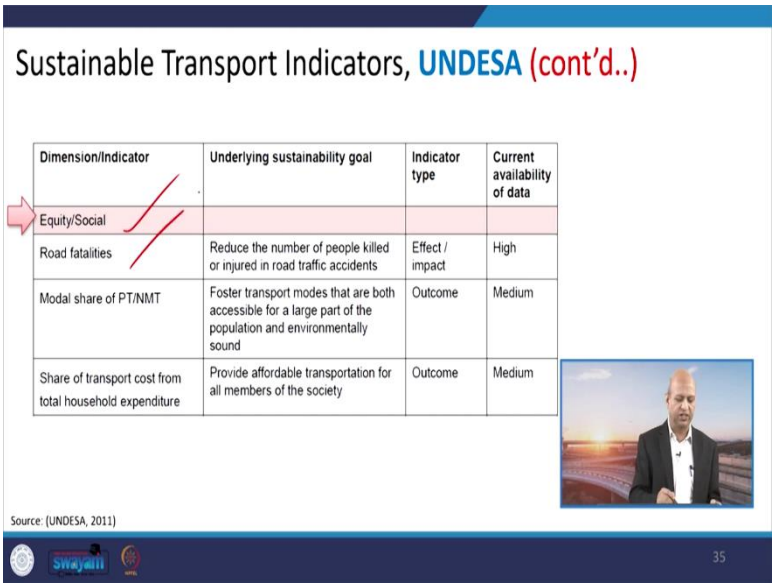

Social, road, fatalities, all those things are included in this.

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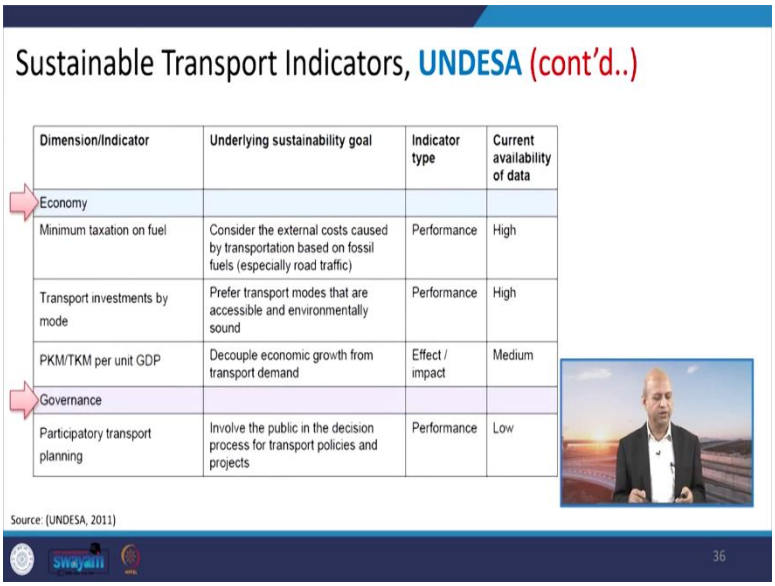

Economy, governance.

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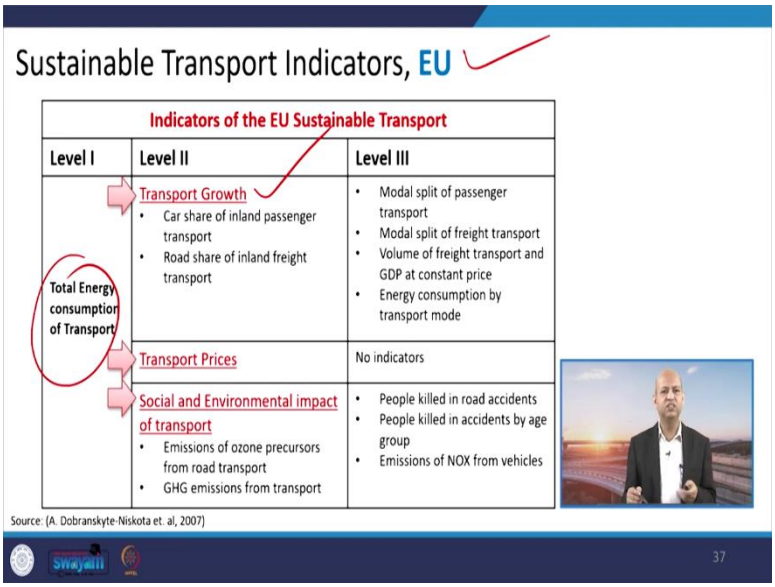

And when we talk about European Union, they have also given some sort of sustainable transport indicators. So, they are of different levels, level 1, level 2, level 3. So, you can see like total energy consumption. Then this is part of transport growth, transport prices, social and environmental impact of the transportation. All these are included in this particular.

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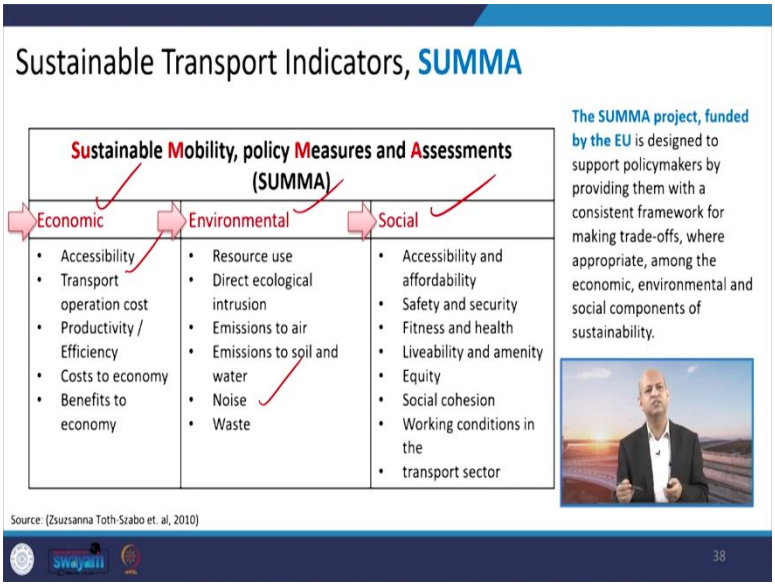

Similarly, this EU's project is there on Sustainable Mobility, policy Measures and Assessments, SUMMA. So, this also have, economic, environmental and social three major basic aspects. So, in that, you can have accessibility, transport related issues, operations costs, etc. Environmental you can have noise, waste, etc. Social accessibility, equity, all those things are there. So, they have given a very easily understandable list which can be followed very easily.

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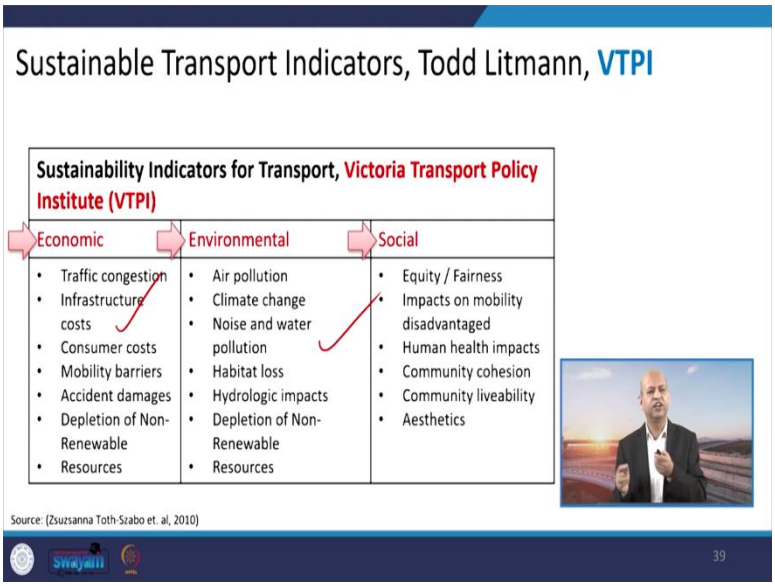

Then there is another effort, sustainability indicates the indicators for the transport, which is proposed by Victoria Transport Policy Institute. They also focus on economic, environmental and social features. And these are listed here. You can see more or less, they are similar different names and different emphasis on various aspects.

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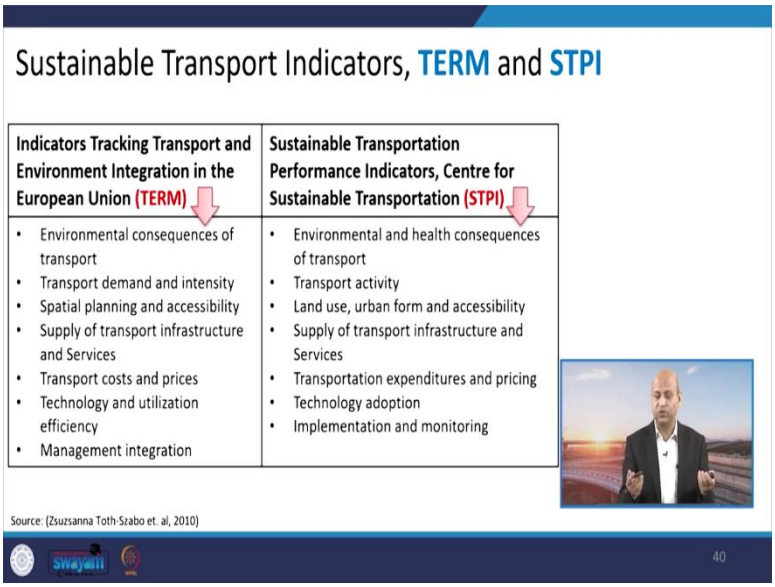

When we talk about these indicators, tracking transport and environment integration in the European Union that is TERM and Sustainable Transportation Performance Indicators, Centre for Sustainable Transportation STPI, which has given proposed these. So, again, and they are related to environmental and health consequences, transport activities, or technology adoption, all those things are there because technology also changes, fuel changes are also there, like from diesel to CNG, 2-wheeler, 2 strokes to 4 stroke engines. Those kinds of things are there. And nowadays people are talking about electric vehicles.

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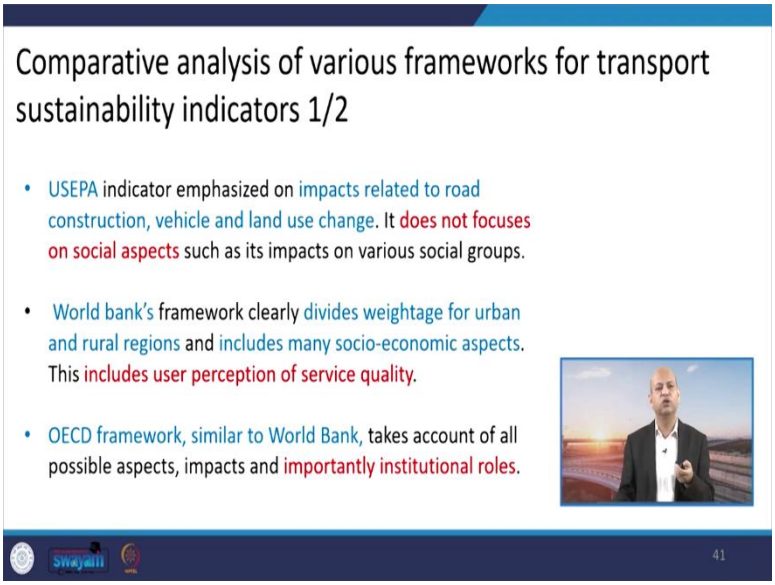

When we talk about competitive analysis of various frameworks, which we have discussed these frameworks proposed by World Bank or EU and OECD, etc. So, when we want to compare these frameworks, then we conclude that this USEPA indicators emphasize on impacts related to the road construction or vehicle and land use change.

It does not focus much on social aspects, such as impacts on various social groups. This is one feature. World Bank's framework clearly divides weightage for urban and rural regions and includes many socioeconomic aspects. And this also includes user perception and service quality. Similarly, if you talk about OECD framework, then similar to the world bank, it also takes account of all possible aspects impacts and import these are important aspects of institutional roles.

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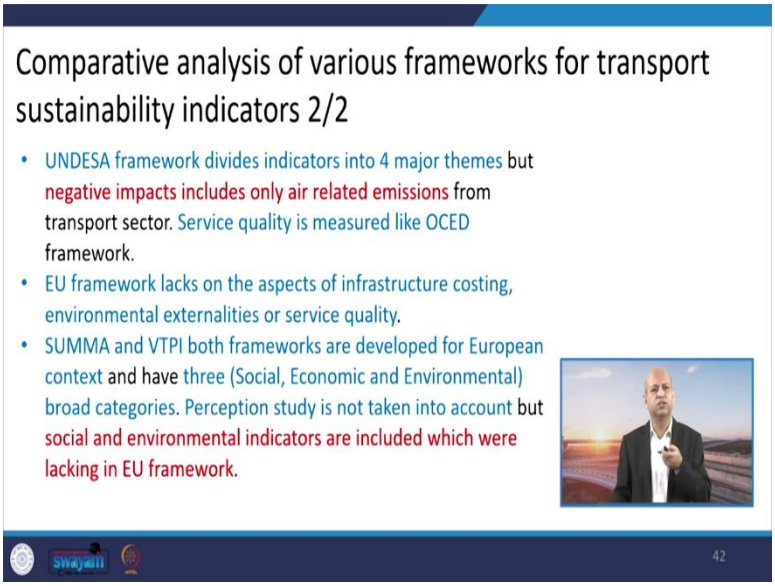

When we talk about UNDESA framework, it divides indicators into four major themes, but negative impacts includes only air related emissions from transport sector and service quality is measured like OCED framework. When we talk about EU framework, which lacks on the aspects of infrastructure costing and in this environmental externalities or service quality.

Whereas EU's project like SUMMA and VTPI these both frameworks are developed for European context and have three major aspects like social, economic and environmental, which we have seen. These are the broad categories they focus on. And the perception study is not taken into account, but social and environmental indicators are included, which were taking or which was lacking in the EU framework. So, this is taken into account in SUMMA and VTPI.

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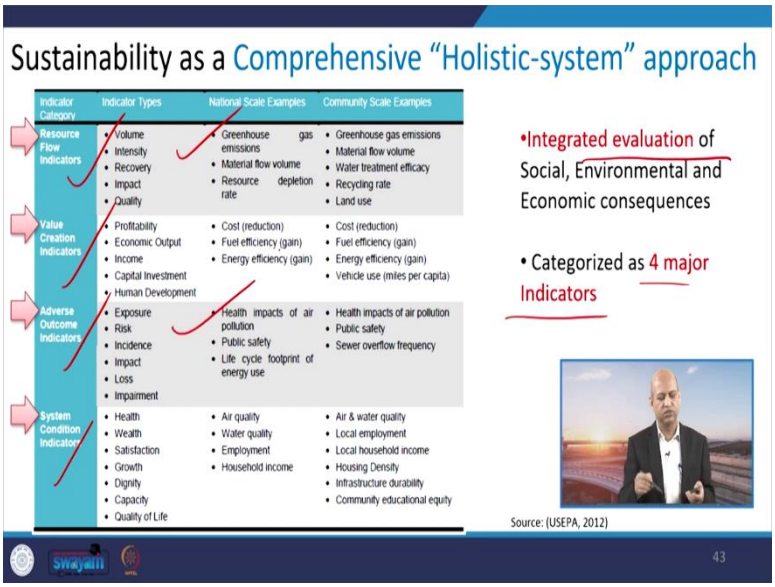

When we talk about like sustainability as a comprehensive holistic system approach, then integrated evaluation has to be carried out. So, that should integrate social, environmental and economic consequences. Similarly, these four major indicators maybe there, you can see here, resources, value creation, adverse outcomes, system conditions, etc., and several other, finer aspects are given like greenhouse gas, cost, health aspects, all these things you can see here.

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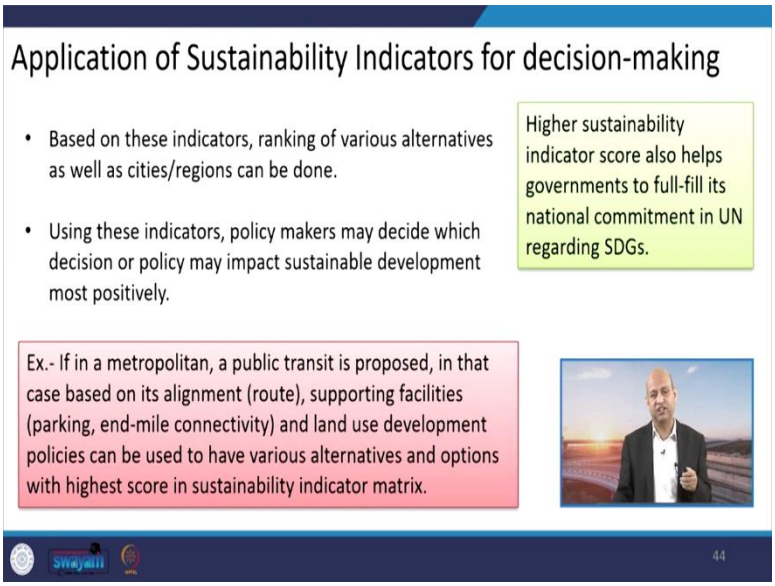

Similarly, when we talk about the application of sustainability indicators for decision-making, then it should be based on these indicators, like ranking of various alternatives, as well as like cities or regions, which can be done by using these indicators. Similarly, using these indicators, policymakers may decide which decision or policy may impact sustainable development most positively.

So, that we can go in their direction. So, higher sustainability indicator score also helps governments to fulfil its national commitments towards SDGs of the United Nations. One example is like in a metropolitan, public transit is proposed in that case, like based on its alignment, like routes and the supporting facilities like parking, end-mile connectivity and land use development policies can be used to have various alternatives and options with highest score in sustainability indicators matrix. So, that can help in that direction.

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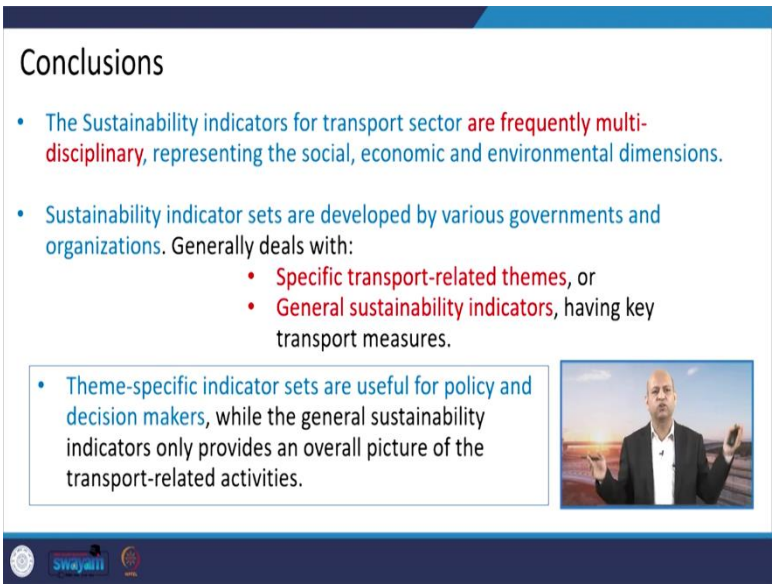

Well, at last, we can conclude that the sustainability indicators for transport sector are frequently multidisciplinary. Because several aspects are included and they are representing the social, economic and environmental dimensions in totality and sustainability indicator sets are, different sets are there, as you have seen, these are developed by various government agencies and organizations, which we have seen, like OECD, World Bank, etc.

And they generally deal with the specific transport related themes or general sustainability indicators, depending upon what is the priority. So, theme specific indicator sets are useful for policy and decision makers. While the general sustainability indicators only provides an overall picture of the transport related activities.

So, this is in nutshell part of the sustainability indicators, which can be used to assess whether a system which is being proposed is sustainable or not, especially the transportation systems, because we are talking about sustainable transportation. So, this is all for today.

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And you can go in detail through these references for additional information. So, this is all for today. Thank you for your attention and see you in the next lecture. Thanks.