Business and Sustainable Development
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Lecture - 05
Environment, Human and Economy

Hi, welcome to the session on Environment, Human, Economy, Exploring Links in Model. So, in this session, we will try to see how these models listed over here, how they are creating a link between human, environment and economy.

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And also we will see that how the sustainability how it is being presented from the economics viewpoint where we will operationalize two type of sustainability that is weak sustainability and strong sustainability.

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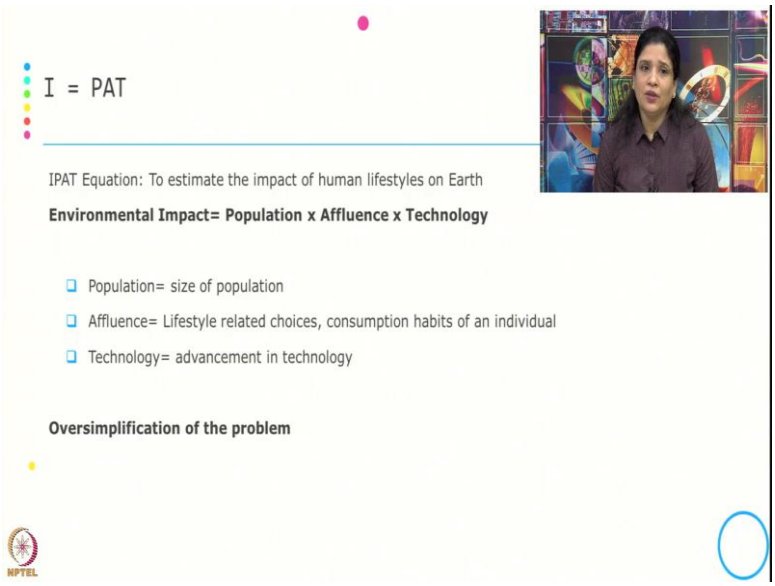

So, to start with let us see what the first model which is creating a link between human, environment and economy. So, this is known as IPAT. And the equation is environmental impact, which is equal to population affluence and technology. So, the impact stands for I, P stands for population, A stands for affluence, and T stands for technology.

Now, this IPAT equation is use to estimate the impact of human lifestyle on earth. Now, how do we represent these different variables? Population, this gives us the size of population. Affluence – lifestyle related choices, mostly the consumption habit of an individual which for those guided by the fact that how much the individual earns or the income.

And technology is that what is the advance and advancement in technology these are represented through this variable technology. So, there are critics over this model is that everyone finds that the impact or the problem altogether is oversimplified through this IPAT equation.

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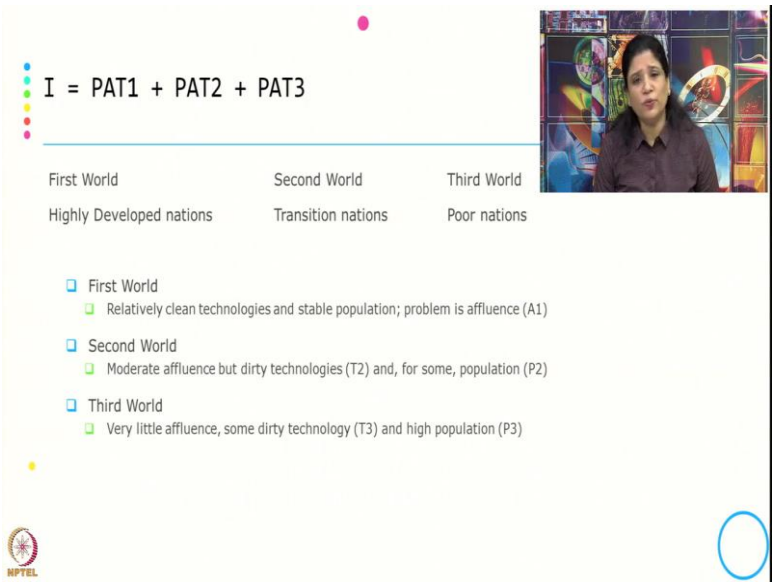

Now, let us see how do we; how do we operationalize this or how we understand this IPAT equation and the context of different countries. So, if you look at the entire impact is divided into three PATs that is PAT1, PAT2, and PAT3. We consider the PAT1 impact is comes from the First World that is highly developed nation. PAT2 is from the Second World that is transit transition nation. And Third World, PAT3, PAT3 is from the Third World that is from the poor nation.

Now, let us see what creates the impact in First World. So, if you look at a feature of it, it is relatively clean technology stable population but the impact comes from affluence, because that is a advancement in the technology so, they are not using the not so clean or the dirty technology. Their population is more or less stable the problem is affluence for them.

In the Second World, you will find that there is a affluence because there is a growth in the income at least for few groups, but they do not use the clean technology for them the problem comes at the impact comes from the technology and for some because of the population growth. For the Third World, affluence is not a problem. There is very little affluence.

There is some or very few dirty technology and high population. Why affluence is less? Because income is less. Why some dirty technology? Because there is no not lot of activities happening in the Third World, but the population is high. So, if you look at the

impact from all these three groups, typically for the developed nation, the impact comes from affluence; for the Third World, typically the impact comes from the population.

And from the Second World, mostly it is through the some part is from population, some part is from affluence, and the technology is the biggest driver for their impact whatever the impact they there causing through their activity.

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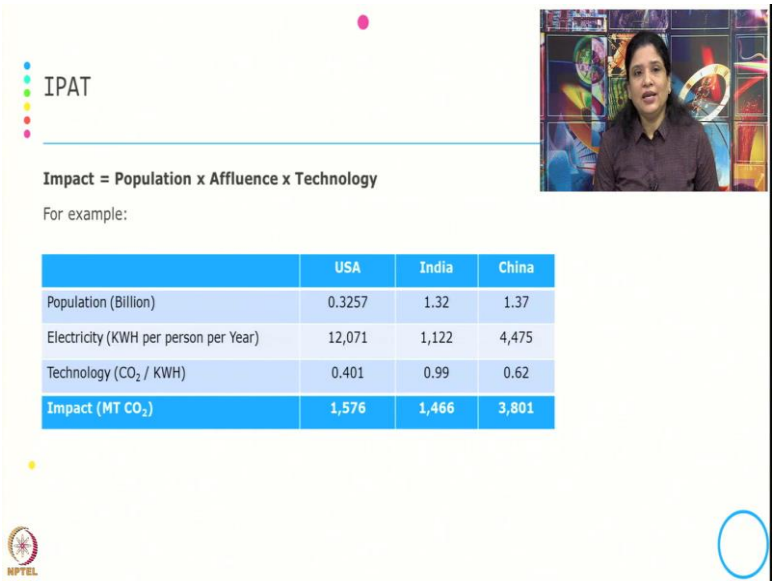

Now, let us take an example to understand this further. So, we have the data about population for all this three countries that is USA, India and China. Then we have electricity that is kilo Watt hour per person per year, and technology for proxy for technology; electricity is mostly the proxy for our affluence, and population is the proxy for population. And how do we calculate the impact? Taking the population affluence and technology.

So, if you look at the impact is very high for China, mostly for population also some amount from the consumption that is electricity consumption and also some from not using the or not using the so called clean technology.

And even if you look at the consumption is very high because of the population and because of this technology, the impact from USA is less. This is just a hypothetical example to understand that, what is the impact of population, affluence, and technology on the environmental impact.

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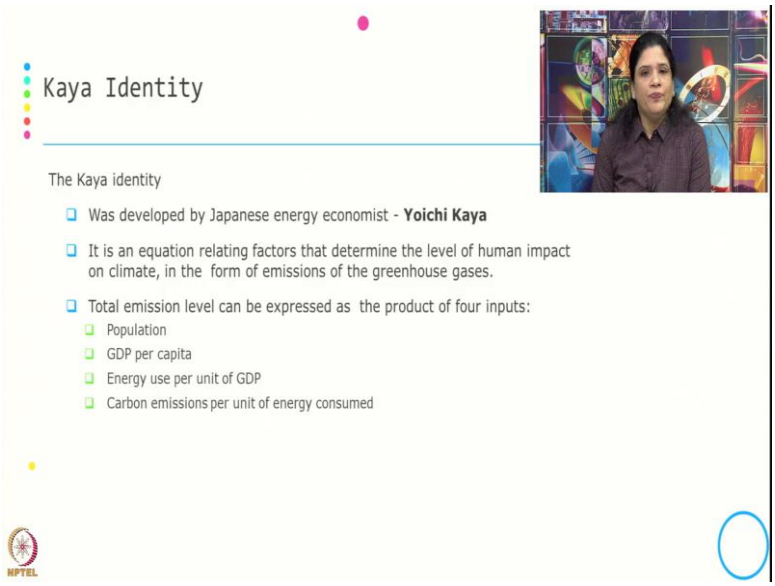

Now, going to the next model to understand, this impact or to understand the linkage between environment, economic and human believes the Kaya identity. And it is developed by Japanese energy economist Kaya. And the equation relating factors that determine the level of human impact on climate in the form of the greenhouse gases.

And here the total emission level can be expressed as the product of four inputs – population, GDP per capita, energy use per unit of GDP, carbon emission per unit of the energy consumed.

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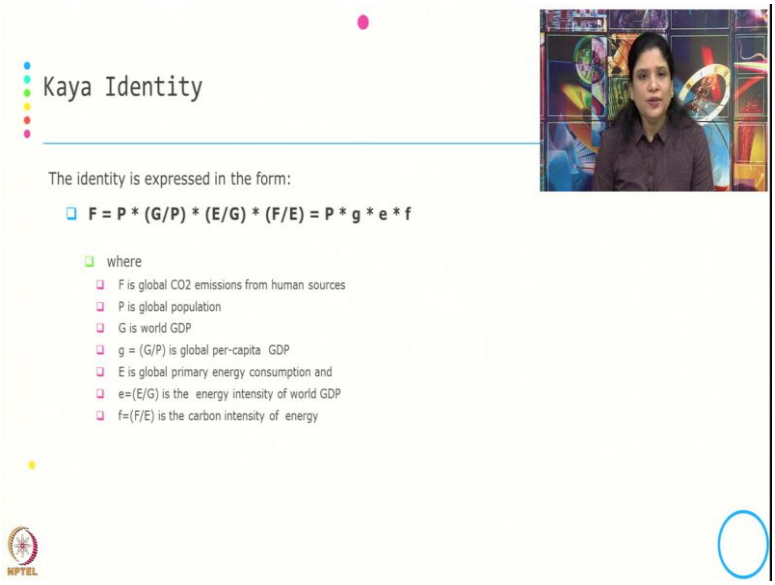

Now, the identity is expressed in the form of F which is a function of P, P is the proxy for global population, G that is worlds GDP, and E is the global primary energy consumption, and F is the global CO 2 emission from the human sources. So, simplifying this, this should be population multiplied by our GDP by population multiplied by energy consumption by GDP multiplied by the global CO 2 emission from energy.

$$\mathbf{F = P * (G/P) * (E/G) * (F/E) = P * g * e * f}$$

where, F is global CO_2 emissions from human sources, P is global population, G is world GDP, g = (G/P) is global per-capita GDP, E is global primary energy consumption, e = (E/G) is the energy intensity of world GDP, and f = (F/E) is the carbon intensity of energy.

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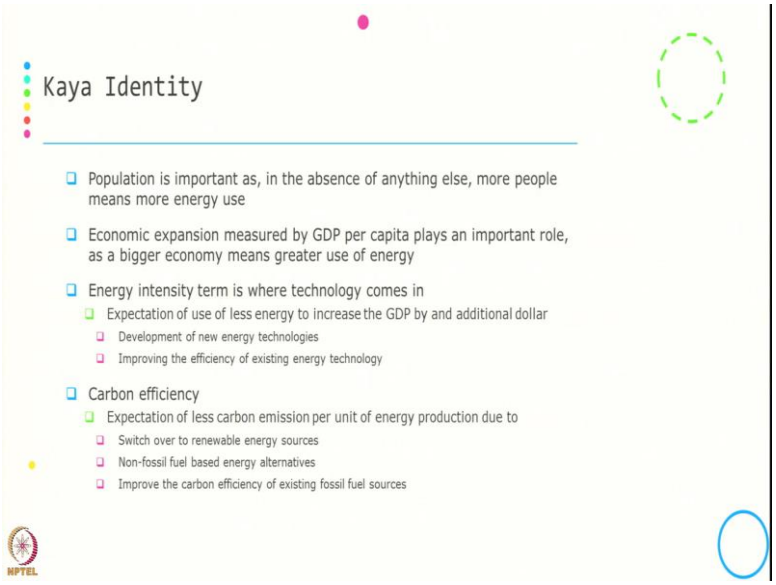

So, once we take this identity, once we take this equation, let us understand that why have you taken this factors into the identity. As we know population is important and why it is important? Because more people use more energy use, and more energy use the more impact.

Then the economic expansion is measured by GDP per capita this plays an important role, as bigger economic is more income, more income is more consumption, and more consumption is the greater use of energy. Then the energy intensity terms typically

where we take the technology that is the expectation to use less energy to increase GDP by the additional dollar.

And why it is expected that we will use less energy? Because there would be developed development of new energy technology that is in the form of the energy efficiency and new energy sorry this is the low energy technology which will require less energy to produce the product and also there would be improvement in the efficiency of existing energy technology.

And the last term why it is important? Because the carbon efficiency. Now, what is expected over this variable? That there is an expectation that less carbon emission per unit of energy production due to switch over to the renewable energy sources, which is no carbon, non-fossil fuel-based energy alternatives, and improve the carbon efficiency of the existing fossil fuel sources.

So, mostly two things will increase the carbon efficiency that is one, increasing the carbon efficiency of the existing fossil fuel sources, and also looking at the renewable energy sources.

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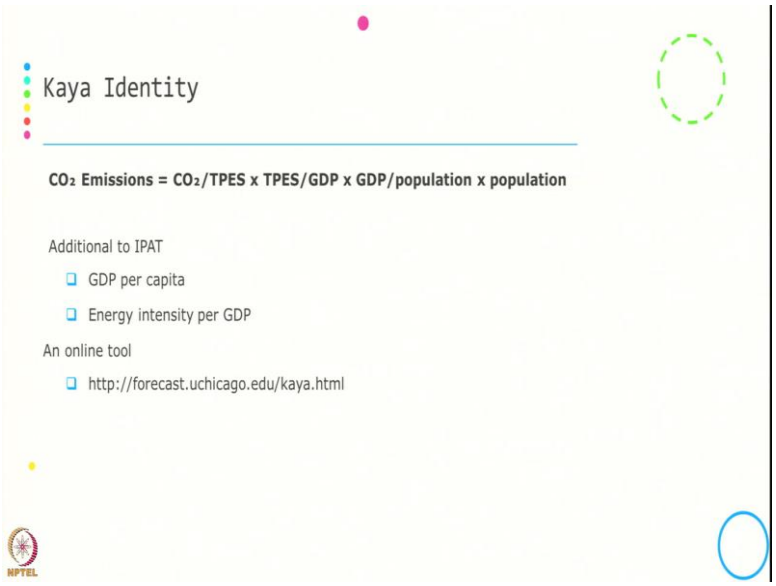

Now, getting into the equation, CO 2 emission is again this is we have taken CO 2 or total product or total population, then GDP, and also the use of the energy consumption and also the carbon content in the energy.

CO_2 Emissions = CO_2/TPES x TPES/GDP x GDP/population x population

Now, what is additional over additional two PAT in this equation? Apart from population, affluence, and technology, we are also considering the GDP per capita and energy intensity per GDP. And there is a, online tool available which can be used to calculate the Kaya identity.

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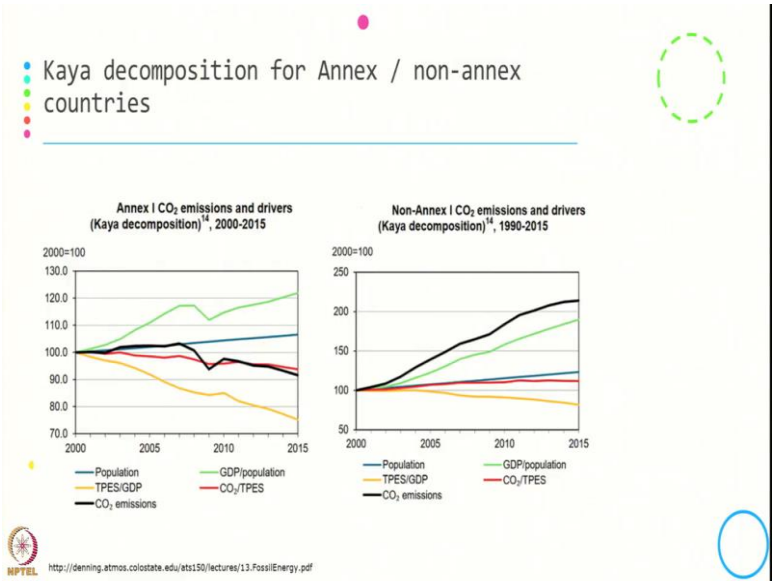

Now, let us take a small example to understand that when we are discussing about all these four variables how they are driving the impact. So, if we look at in the left hand side, this is the annex one CO 2 emissions and drivers that is from 2000 to 2015. And see the other side is the non annex CO 2 emission and drivers. So, if you go into the first slide, the CO 2 emission is increasing.

And if you look at now what is driving the CO 2 impact, mostly the driving impact is GDP per population. And also what is possibly reducing the impact, then we can say that what is the CO 2 content per energy or we can say that is the total energy with respect to the GDP. So, mostly the energy intensity and the carbon in carbon efficiency, they will decide what would be the impact of it.

And in this case the affluence component or let us say the consumption component that is GDP population there, they are typically deciding more about the impact that is created by the country. Now, if you are coming to the non a non-annex CO 2 emissions

and driver, so here if you look at the population is increasing, there is an increasing trend from 2000 to 2015, the CO 2 emission is also showing a increasing trend.

And, but possibly what why it is increasing? The major factory is again GDP per population. But also, we can see that there is the more prominent over here is that we are not using in case of non-annex country we are not using more energy efficiency kind of technology, and also the types of fuel we are using that is more of the carbon.

So, this Kaya decomposition it can be done country specific, it can be done in the different scale, sometimes it is done in case of sector, and also sometimes it can be done in the case of the industry. It can be done in all this scale.

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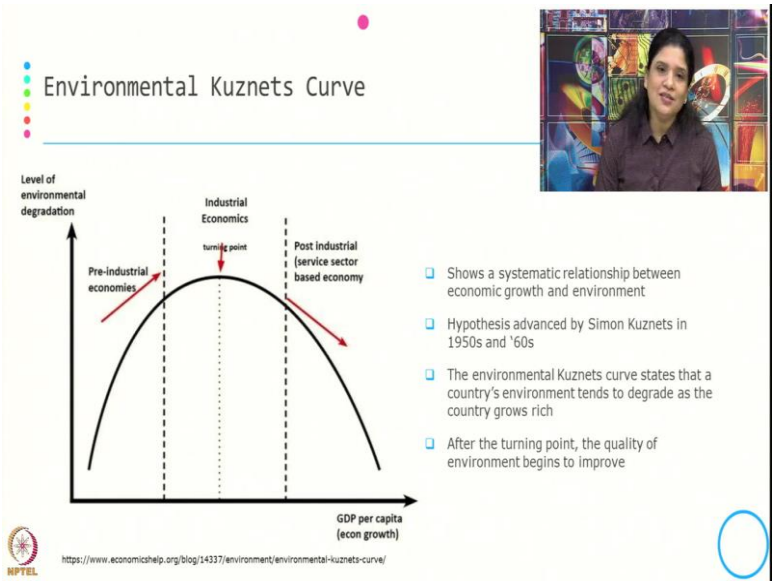

Now, going to the third model, what we are going to discuss today is the environmental Kuznets curve. This is from a, this is typically consider as the most important model to understand the relationship between the environment and economy. Now, what it shows? It shows a systematic relationship between economic growth and environment. And this hypothesis was developed by Simon Kuznets in 1950 and 60.

So, initially this environmental Kuznets curve, this Kuznets curve was mostly to study the relationship the study about the income inequality; at the later point, this hypothesis added the environment over this and this is known as the environment Kuznets curve. It

states that country's environmental trend, country's environment tend to degrade as the country grows rich.

And after the turning point, the quality of the environment begins to improve. So, if the country is going through the growth phase, typically you will find that the growth phase has been characterized as initially there is a pre industrial economies, then the industrial economy. And finally when the sectoral shift happen or the structure of the economy change from the industry to service, then the entire growth is based on the service sector.

So, initially growth is based mostly on the agriculture, and partly it is industry, then it is based on the industrial activity, and then it is based on the service sector activity. So, according to this environmental Kuznets curve, initially when the growth happens typically with this the environmental degradation also happens. Once it reach the turning point, beyond this, whatever the growth happens that leads to decrease in the environmental degradation or we can say that environmental quality increases.

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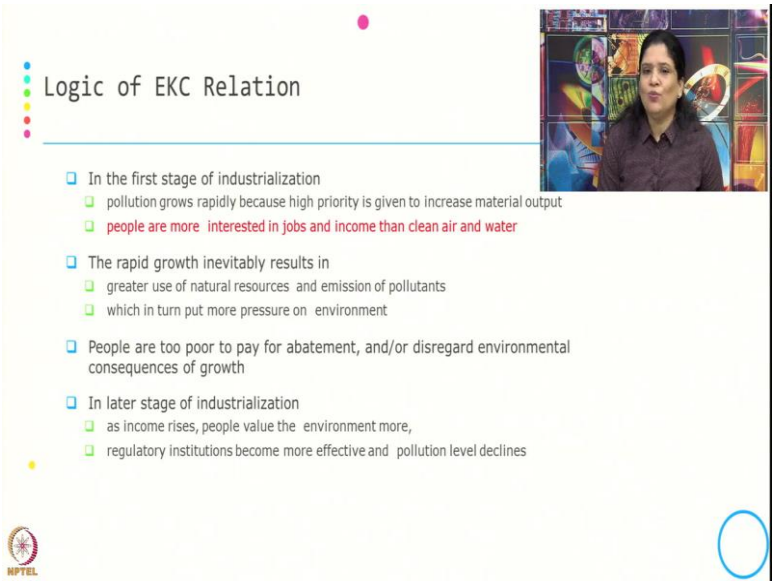

Now, what is the logic of this EKC relationship? So, in the first stage of industrialization, pollution grows rapidly because high priority is given to the material inputs. The typical example is that at that point or the focus of the economy at that point is then, how to create more employment opportunity, how to create more economic opportunity rather than looking at the activity which is give us clean air or clean water.

So, obviously, whenever the growth happens at the initial phase, you will find that there is more importance to income, but also it is creating more degradation. This rapid growth typically results in greater use of natural resources. One is your using resources also the emission of pollutant will happen because we are not giving more emphasis to the cleaner technology or the better resources, which intense puts more pressure on the environment.

But you cannot expect much over here also that people are poor to pay for the abatement or possibly they will just disregard the consequences of the environmental the so-called environmental consequence of growth. But at the later stage of time when the industrialization happens as the income rises, people value environment more. Regulatory institution become more effective, pollution level declines.

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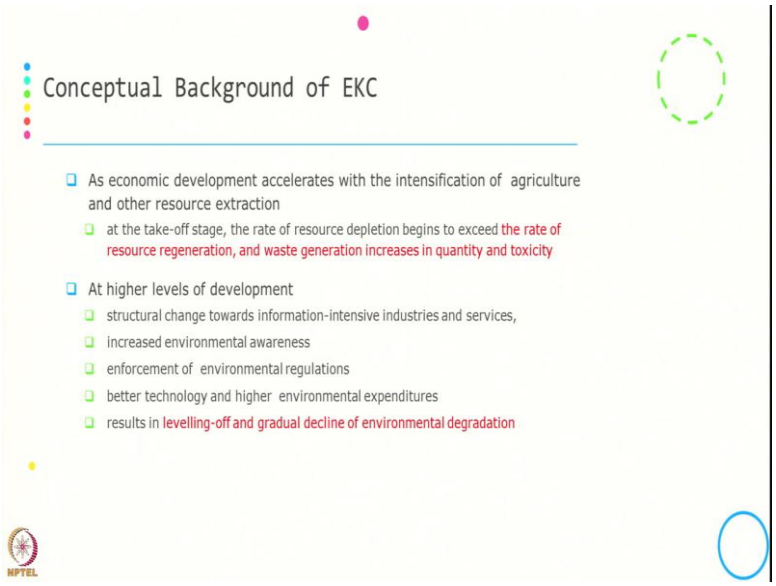

Let me just give a small example from the individual perspective. When we earn more or when our income increases, we try to consume more then we see that whether this is environmental friendly or not. So, in this case, we see that initially with the increase in the income, increase in the growth, we try to consume more rather than try to consume more environmental friendly product.

But when our income increases further, we can when we can afford to go for environmental friendly products, then only we buy the environmentally friendly

products. So, at the initial stage, as an individual we are also ignoring the in the consequence the environmental consequence associated with our consumption.

Now, as the economic development accelerate with the intensification of agriculture and other resource extraction at the take off stage, the rate of resource depletion begin exceed the rate of resource regeneration, and waste generation increases the quantity and toxicity. So, at the higher level of development, these are the things happen.

Structural changes towards information intensive industry and services that is more towards leaning towards the service-based economy, increase the environmental awareness, enforcement of the environmental regulation, better technology and higher environmental expenditure, and all these results in a leveling off and gradual degrade decline of the environmental degradation.

And that is the reason we find that our environmental Kuznets curve decreases or let us say environmental degradation decreases or environmental quality increases.

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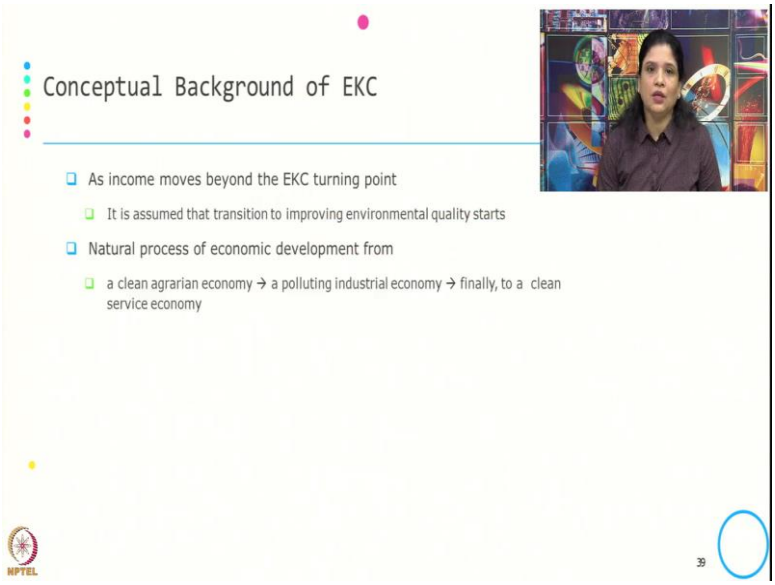

So, as income moves beyond the EKC turning point, it is assumed that transition to improve the environmental quality starts. So, what is a natural process of the economic development? From a clean agrarian economy to a polluting industrial economy and finally, to a clean service economy.

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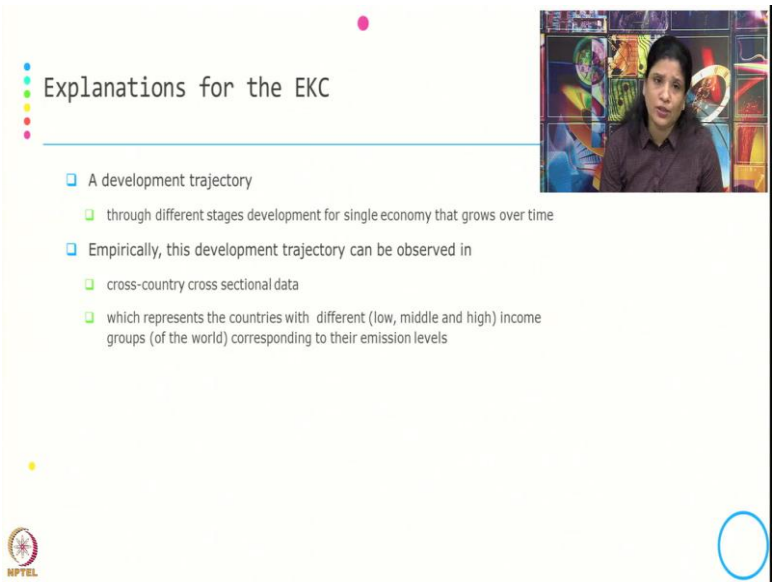

So, let us explain this little bit more with respect to the different stage of development. So, typically, this is a developmental trajectory for a single economy, but when we take all the economy together mostly the transition will not the same for all the economy. So, typically, this is a development trajectory for the single economy that grows over a time for a, from the agrarian economy to the industrial economy and finally, to the service economy.

This is this can be also tested empirically through the cross-country cross-sectional data, which represents the country with different low, middle, high-income groups and also corresponding to their emission level.

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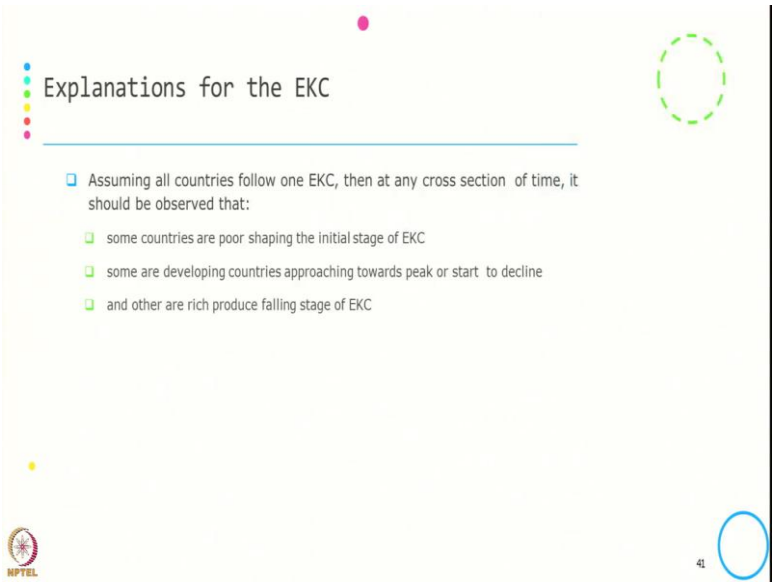

And assuming all countries follow one EKC, then in any cross section of time it should be observed that few of the country they are responsible for the increasing part of the Kuznets curve that is some countries are poorly shaping the initial stage of EKC. Some of the developing country they will be responsible for the peak that is approaching towards the peak or start to decline, and the other rich produce at the falling stage of EKC.

But this is just an assuming that which country will fall under which group. Initially possibly since the developing countries is the poorer country they are not using more of the resources; they will not contribute more. But for the transiting nation for the developing countries when they produce more use more of resources they will contribute to the degradation part, but when their income increases growth increases, they will also contribute to the decreasing part of the EKC.

And developed country although it is assumed that they will always contribute to the decreasing part of environmental quality, but there is also evidence that they are the one also who comes contribute to the peak part of it. And interestingly empirical investigation will show the different turning point of each of the country and how they are contributing to the environmental Kuznets curve.

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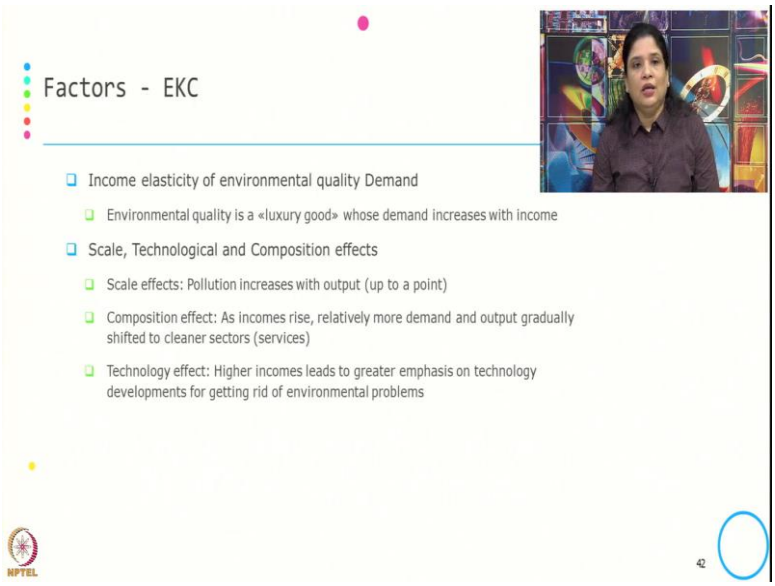

Now, what are the factors responsible for EKC? There is an income elasticity of environmental quality or demand. Like typically consider environmental quality is a luxury good and whose demand increases with the income. So, let us say when our income increases, we buy a house right. But when we buy a house with clean air, clean water that becomes a luxury goods that we can afford only to go for the when where income increases further. So, in most of the cases, environmental quality is considered as the luxury goods.

Then there are three effects responsible for this EKC. Scale effect – pollution increases with the change in the scale of the output. Composition effect – as income increases relatively more demand and output gradually shifted to the cleaner sector. The composition means we are moving from agriculture industry mix to the industry service mix where the service sector contribution is high.

Technology effect – with the high income, we can give more emphasis on technology and we can use better technology to get rid of the environmental problem.

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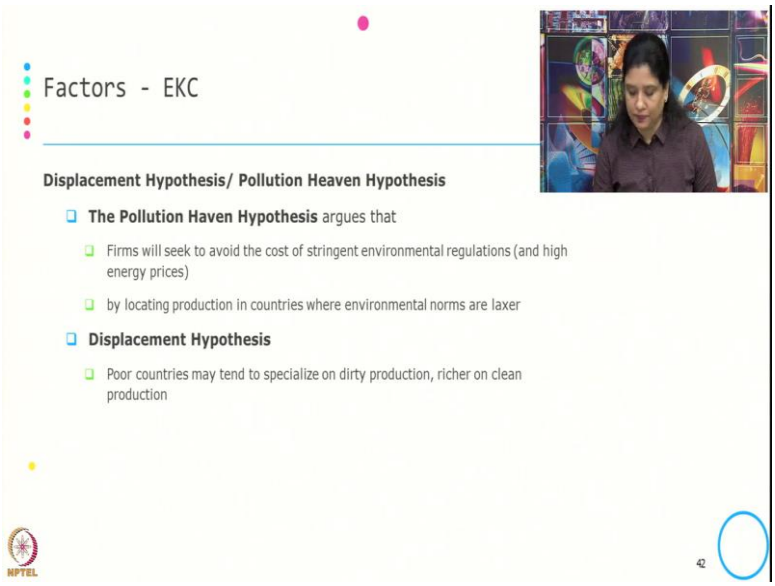

Then apart from this, there are other two hypothesis who are responsible for this EKC. One is the pollution hypothesis; second one is the displacement hypothesis. What is pollution haven hypothesis? It argues that firm seeks to avoid the cost of stringent environmental regulation and high energy price, and that is the reason they locate their production into the country when environmental norms are the laxer.

And what is the net outcome? The net outcome is that even if there are not much capability with the developing country while the environmental norms are little relax, you will find that more impact is coming from there. And displacement hypothesis says that over a period of time you will find that the poorer country and the developing country they are specializing more on the rather than specializing more on the production of goods and services which are creating more impact because these are been given to the developing country, and the reach on the cleaner production.

And while developing country even if they know that this is dirty technology, it is creating more impact till they do it because for the poorer country the focus is more on creation of employment opportunity and income.

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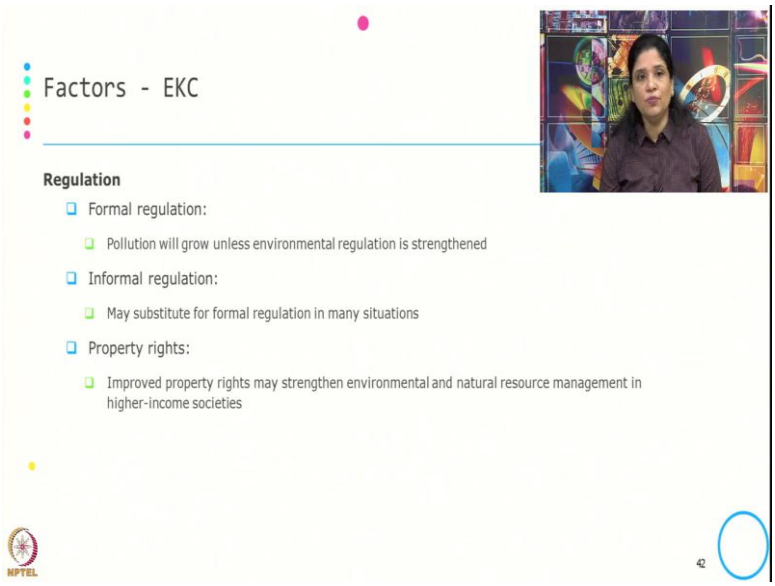

Then there is a role of the regulation, formal regulation, informal regulation, and also the property rights. So, if you remember at some point of time, we are discussing about the common resources. And if there is common resources, there is more environmental degradation. So, in that case, the property right may strengthen the environmental and the natural resource management in high-income society.

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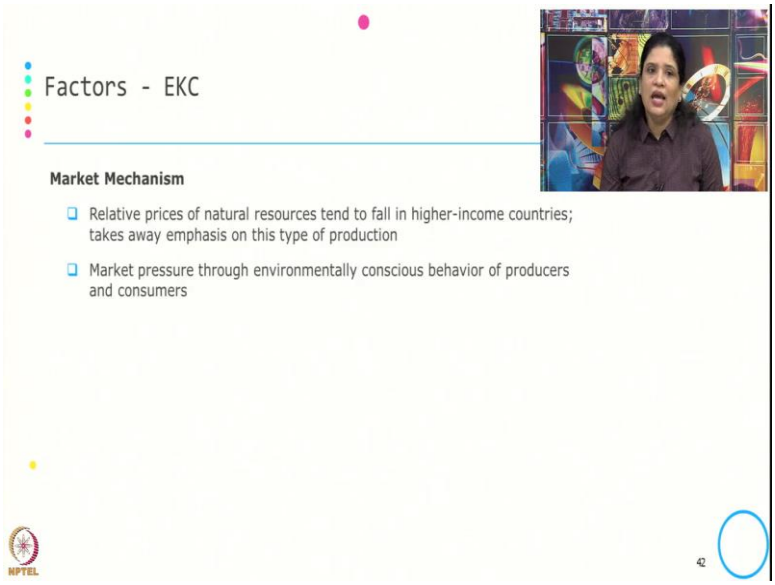

And then the market mechanism mostly through the price of the natural resources, and the environmental conscious behavior of the producer and consumer through market pressure also create a also has a influencing factor on the shape of the EKC.

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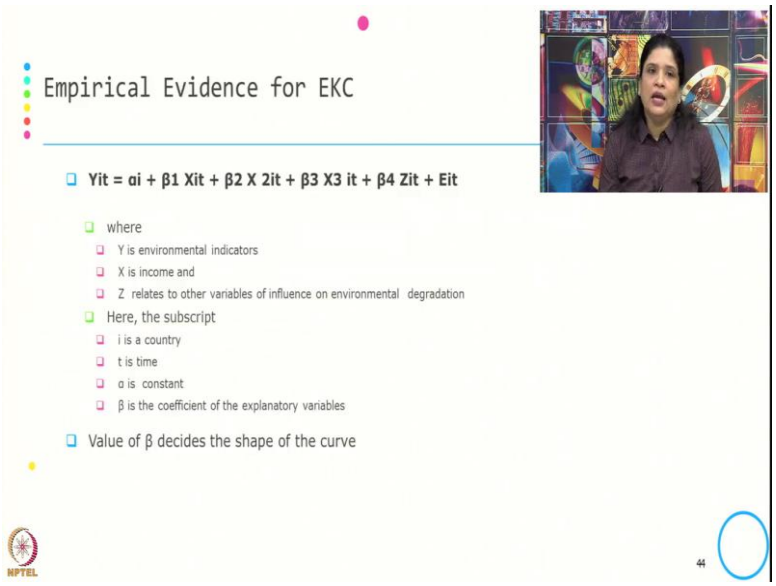

Now, this is how we can create a empirical evidence of EKC through this equation

$$Y_{it} = \alpha_i + \beta 1\ X_{it} + \beta 2\ X2_{it} + \beta 3\ X3_{it} + \beta 4\ Z_{it} + E_{it}$$

where Y is the environmental income indicators, X is the income, Z is related to other variable influence of environmental degradation. And typically, the value of beta different beta that decide the shape of the environmental Kuznets curve.

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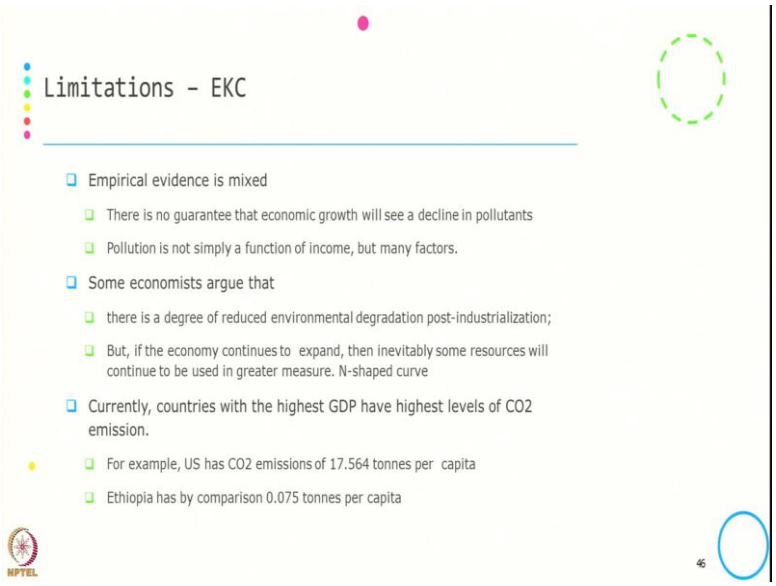

This EKC has been criticize that although it talks about a clear relationship between the environment and economy. There are also some limitations or there is some criticism that the empirical evidence is mixed. There is no guarantee that economic growth will always see the decline in pollutant.

What I was trying to also refer when I was discussing the case of the developed country. So, even if the developed country their GDP is high, the economic growth is high, it does not mean that will help in declining the pollutant if they are not putting effort on the clean technology or if they are not getting into the alternative resources.

Similarly, pollution is not simply function of income, there are many other factors which has not being consider in the equation of the environmental Kuznets curve. Some economist argue that there is a degree of reduce environmental degradation post industrialization.

But if the economy is continue to expand at least they will be going on using some resources, they cannot expand without any resources they will go on using some of the resources and possibly rather than the inverted U-shape although it will decrease to the lowest at a point. But beyond a point, again it is going to increase further the degradation is going to increase further.

Because even if the economy is expanding, it is not going to stop the consumption of the resources; and if they are not going to stop the consumption of the resources, that degradation is going to happen. So, most of the also you will find most of the empirical evidence, it suggest a N-shape curve rather than an inverted U-shape curve.

Currently country with highest GDP have highest level of CO 2 emission, so that way we cannot justify that the falling part of Kuznets curve is mostly because of the developed country. Although theoretically we assume that since their growth is more they can spend more on technology they can or possibly they will not expand further their contribution would be less, or they will also invest on the better environmental quality or better technology.

But if you look at the fact the USA CO 2 emission of this per capita, and US is considered to be the most developed nation across the globe. But that contrasting result over here is that the Ethiopia's per capita and per capita CO 2 is just 0.075. So, if you look at this fact, possibly we cannot accept the theoretical framework or cannot accept what we get in the conceptual framework that the poorer are responsible for the increasing part of EKC, and the richer are responsible for the decreasing part of EKC.

So, in the next session, we will try to understand how do we operationalize sustainability through the weak and strong sustainability. And in this session, we have tried to summarize these three models IPAT, Kaya identity, and EKC, how they create a link between human, environment, and economy.

Thank you.