Energy Resources, Economics, and Sustainability

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Week – 07

Lecture – 01

Lecture 32 - Understanding Sustainability

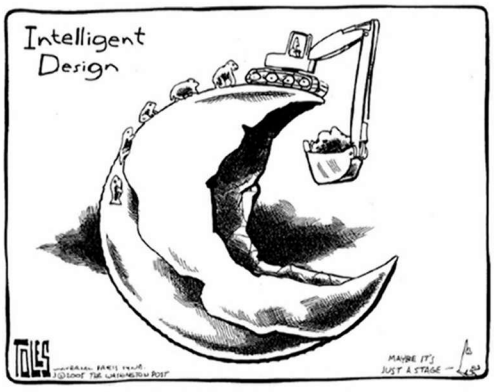
Hello everyone, welcome to the course Energy Resources, Economics and Sustainability. In the past few classes, we have been trying to discuss the different kinds of environmental impacts that come from the different energy production pathways, both renewable and non-renewable, both conventional, non-conventional, both from the so-called clean and green resources and the so-called not so clean resources. We have seen that all different types of pathways do have some amount of impact on the environment. Some might be impacting in terms of the CO2 emissions, others might have an impact on the water consumption, some others might have impacts on the emissions in the gases of SO2, some others might have impact in terms of the land use. So in such a scenario, it becomes very important to understand which particular path is really sustainable. Is the problem so simple that we can say that one particular pathway is better than the other? Is there a mathematical tool? Is there some matrix? Is there a way to say that this particular pathway is going to be better than the other pathway in all the different aspects? Or do we have to go with some kind of trade-offs? These are some of the aspects that we will be understanding in today's class. So let us start with a simple quotation that came in a decade or so back.

"We are coming of age on a finite planet and only just now recognizing that it is finite. So how we manage infinite aspirations of a species that's been on this explosive trajectory, not just of population growth but of consumptive appetite - how can we make a transition to a stabilized and still prosperous relationship with the Earth and each other - is the story of our time".

-Andrew Revkin

Source: A. C. Revkin. Climate, "not the story of our time." New York Times, December 2008.

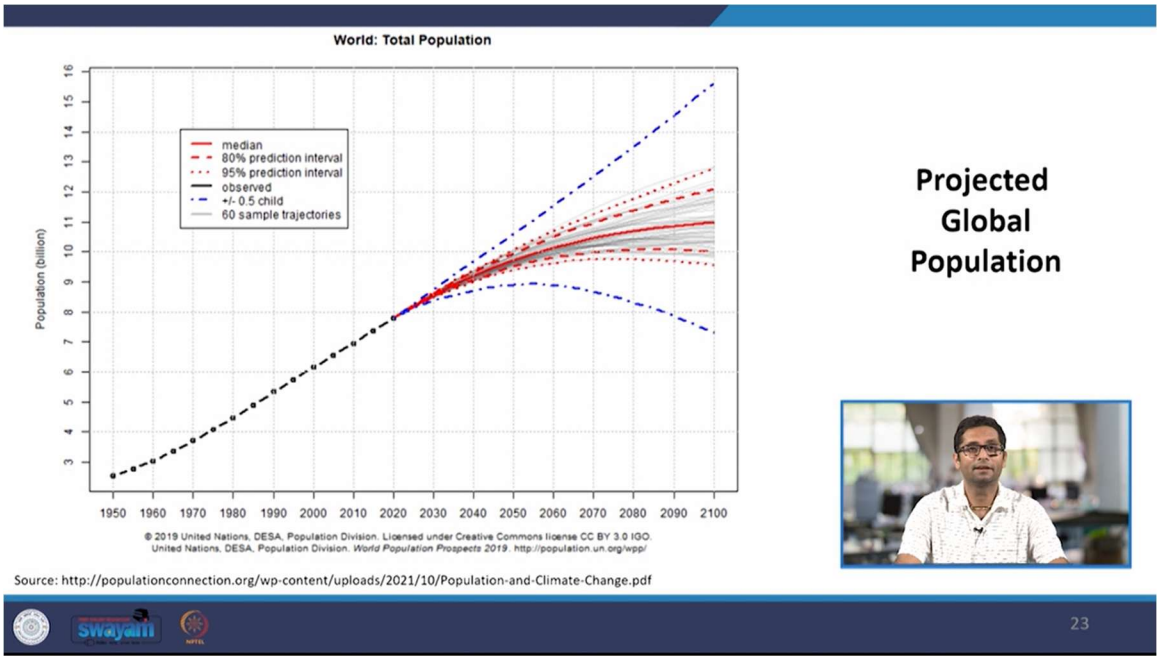
And it was really interesting to read what it said like, we are coming of age on a finite planet and only now recognizing that it is finite. So how we manage infinite aspirations of a species that's been on this explosive trajectory, not just of population growth, but of consumptive appetite. How can we make a transition to a stabilized and still prosperous relationship with the earth and each other is the story of our time. This particular line gives us the paradox that we face. We need to increase our energy production, but we also need to do it sustainably. We also need to take care of the planet. We have been understanding that no matter which energy pathway that we have been undertaking has had different types of consequences on the environment.



Cartoon in the Washington Post on March 29, 2005, after the Millennium Ecosystem Assessment was published. Image courtesy of Andrews McMeel Syndication

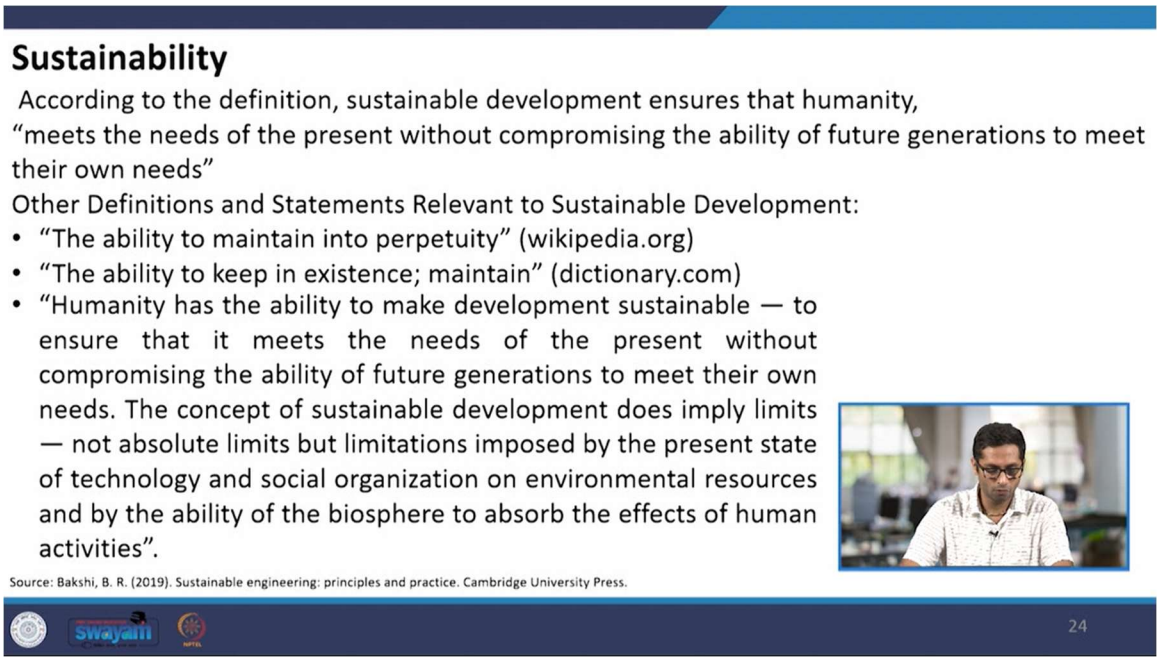
Source: https://wilsonconservationecology.com/2011/04/06/resolving-the-%E2%80%98environmentalist%E2%80%99s-paradox%E2%80%99-and-the-role-of-ecologists-in-advancing-economic-thinking/

And this could also be given by the simple cartoon that in the different years or in the past with the aim of economic development, we have been eating up a lot of resources and that has resulted in a lot of problems in that we face together as a society. So there have been the different types of diseases that we have taken in the past, but if we see today, not all of them were sustainable. And this is why the sustainability is now gaining a lot of importance in any aspect of life that we go for. We look for sustainability in every product that we want to buy. If we want to buy in the stocks, we would look for the companies which have a good ESG profile or the environment social governance profile. We would also want to invest in countries or go towards countries which are more sustainable than the others. We would also want to go to universities or colleges which have a good sustainability ranking. So sustainability is the buzzword or the keyword around us today. But if we try to understand the definition of sustainability, and there are wide variations. Before that, we have been wasting a lot of resources around the world. And this has also been nicely coupled with the population rise. So if you see the population rise that we have been experiencing in the past couple of decades that has been exponential. And it is also expected to grow in the future.



So this is how the population rise has been expected to grow in the future. And it's a business as usual case is that like we are going to peak maybe in the next 70 or the 80

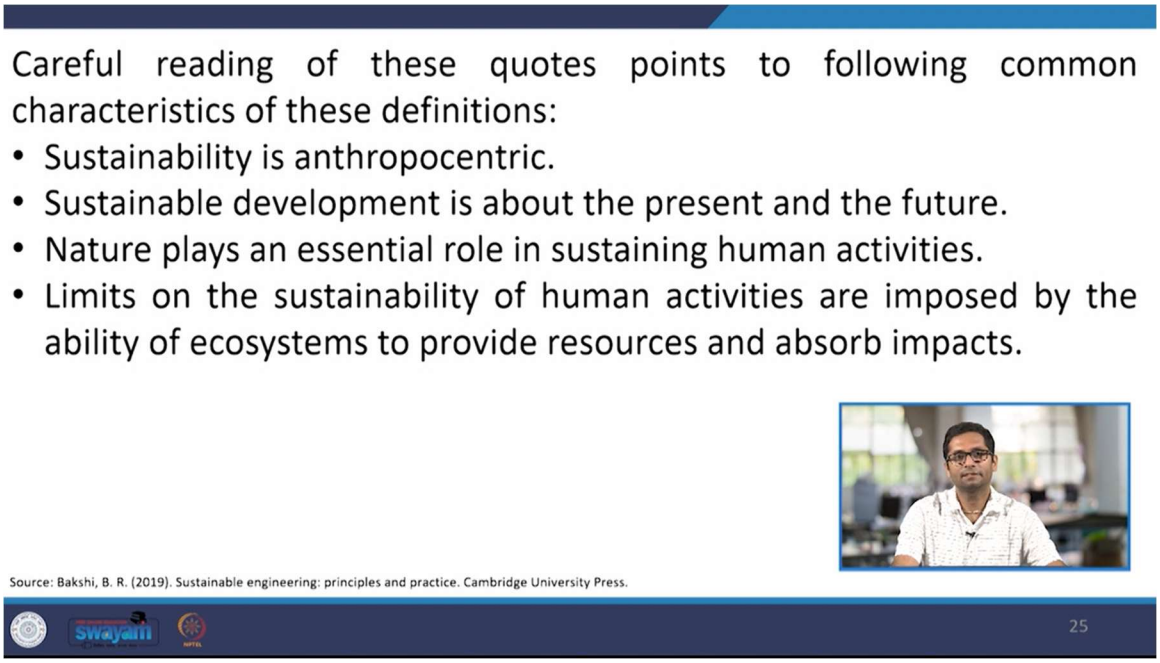
years, but till then, the population is going to rise and with the growing population, there would be also a growing appetite for more and more resources and more and more energy that needs to be consumed. With that, we have to make a strong choice with respect to sustainability. And sustainability is something that we now come across very often. We want to buy products that are much more sustainable. We want to work in the companies which are so called sustainable. We want to buy stocks or shares for the companies which have a good ESG profile. We would want to move towards countries which are more sustainable. We would want to go for education institutes or colleges which have a good sustainability ranking. But how do we understand the word sustainable?



Well, the definition of the sustainable, word sustainable ranks back to a report by the United Nations and it was called the Brundtland Commission and that came up with the definition of sustainability as meeting the needs of the present without compromising the ability of the future generations to meet their own needs. Similarly, if we go towards different types of portals, you would find something similar definition. If I go towards Wikipedia, it has a definition which says the ability to maintain into perpetuity. Another side would say the ability to keep in existence, maintain. Then another particular definition could be humanity has the ability to make development sustainable to ensure that it meets the need of the present without compromising the ability of the future

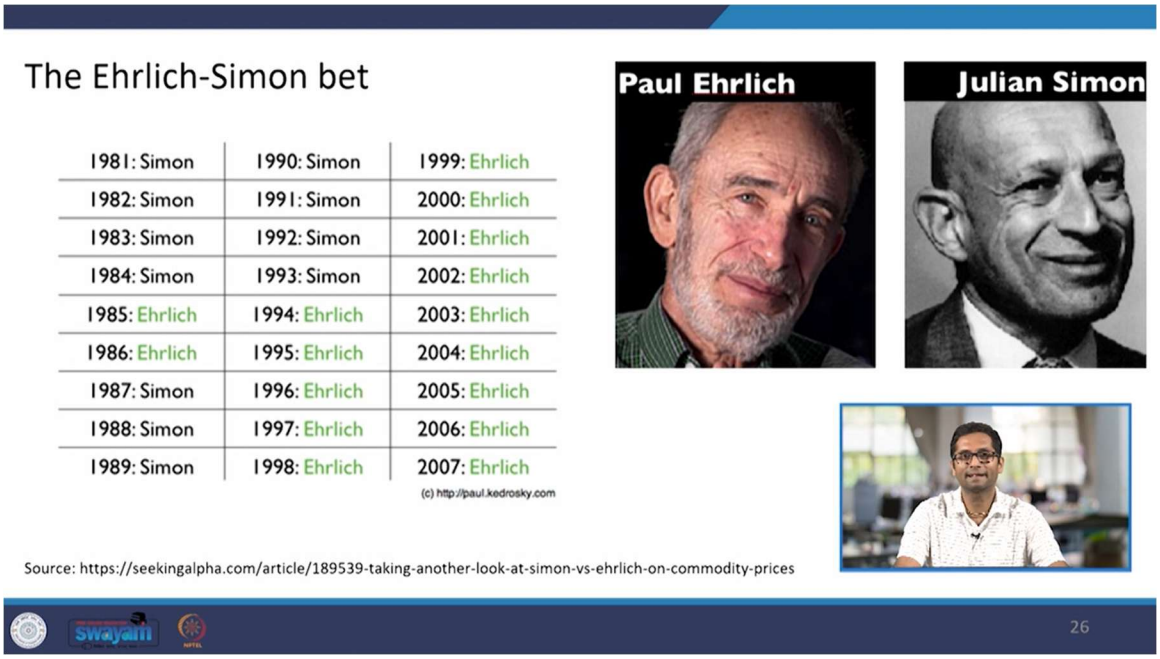
generations to meet their own needs. The concept of sustainable development does employ limits, not absolute limits, but limitations imposed by the present state of technology and social organizations on environmental resources and by the ability of the biosphere to absorb the effects of human activities. Even if we go in the past, we would have statements by people like Mahatma Gandhi. So I'll just read one statement by Mahatma Gandhi. It said, I suggest that we are thieves in a way.

If I take anything that I do not need for my own immediate use and keep it, I thrive from somebody else. I venture to suggest that it is the fundamental law of nature without exception that nature produces enough for our wants from day to day. And if only everybody took enough for himself and nothing more, there would be no properism in this world. This would, there would be no man dying of starvation in this world. But so long as we got this inequality, so long we are thieving. So eventually like Mahatma was also pointing towards a statement of sustainability.



So in the case of, there have been different definition of sustainability, but they have these four major concepts that is there in any definition. First thing is that the sustainability is anthropocentric, which means it's centered around the humans. Second, it is based upon the present and the future. The development needs to be accomplished in such a way that it is good for the present generation as well as for the future generation.

It is essential to give the nature its new role. You cannot just neglect nature, the capacity of the nature to absorb the different kinds of disturbance that have been causing. Further, it also puts the limit on the sustainability of the human activities. We cannot just keep on with the growth that we have been doing for the past centuries. It's certainly not sustainable. We need to put in a break somewhere. We need to understand the nature's capacity and the capacity of the different ecosystems, which are there to bring equilibrium. So these are some of the common aspects that we are going to and that are going to be any definition of sustainability, which means it is centered around the humans. It takes into account both the present and the future. Further, it acknowledges the role of nature and it also aims to put a limit on the human activities such that the equilibrium between the nature and the human activities is taken in for a long term. We also need to understand that the concept of sustainability is not something very new. It has been there in the past as well. One of the earlier experiences has been a famous vigor or the bet between Elrich and Simon.

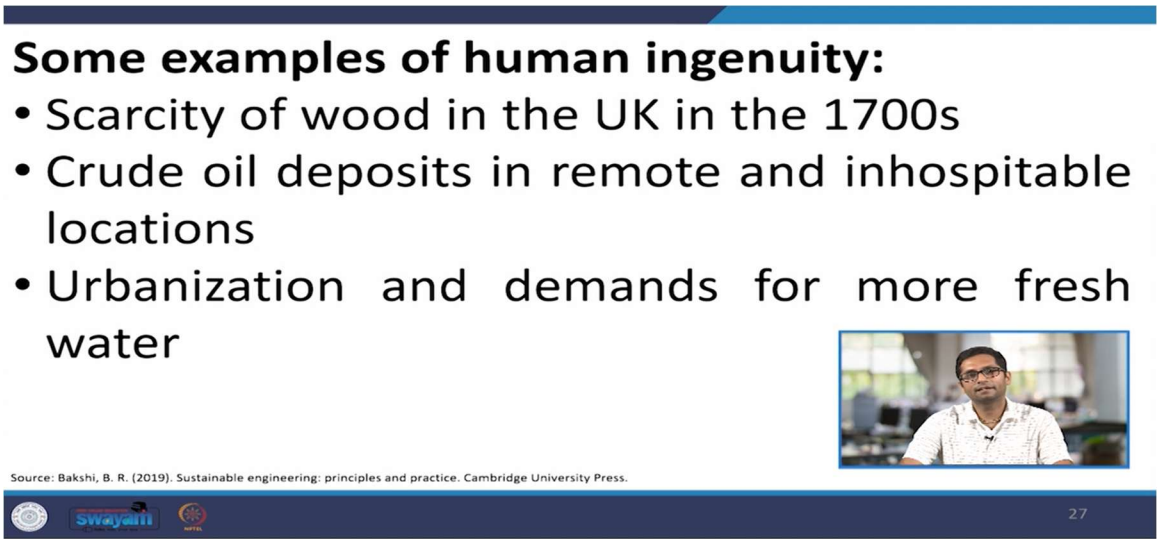


So it started with Paul Elrich, who was a professor at the Stanford University, and he came up with a famous book which says like at the rate of consumption that we are going, it might cause to a lead of a decrease of resources or the extinction of resources quite fast. And his theme was known because of their predictions of a doomsday or

something similar. They were known as the doomsdayers or the alarmist. To counter them came up a team of economists which was led by Julian Simon and he was working at the University of Maryland and the team was called the doomsdayers or the cornucopians. And they were of the opinion that because of the market mechanism, the human society has the inherent ability to adjust to the growing needs and there would be no doomsday. And the human society has come up with its own innovation such that there is going to be no major havoc because of the depletion of a few elements or a few minerals. So Paul Elrich, who was coming from a scientific background, had its own scientific viewing that the rate of consumption was much more than the rate of production or regeneration in the nature. And if we keep on going with the same rate, there could be great consequences. Whereas Julian Simon was coming from an economic background and he had much trust in the market theories which basically meant that or he basically bet on the ability of the human society to counter changes and to adjust to the changes with the proceed of time. So what happened? They had a bet being placed in the year 1980s and the bet was such that they wanted to see the price of increase or the increase in price in the five elements which were quite rare at that time and these elements were chromium, copper, nickel, tin and tungsten. So they put a bet of 200 dollars on each element and the bet was that like in the year 1990s which was 10 years after the bet was placed, will the prices of these elements be higher than what was there in 1980s or would be lower? So Paul Elrich was of the opinion it is going to be higher because these are rare elements and as the consumption grows probably the price is going to be very high. Simon was of the opposite opinion that it would be lower and a bet of 1000 dollars was placed in the year 1980s.

And it so happened in the 1990s the price of 3 out of the 5 elements came out to be lower and the overall price of these 5 metals was lower than as compared to 1980s. So it was Julian Simon who won the bet but if we also understand like if they have chosen any other years for comparison as has been shown in the figure on the left as well, the results could have been very different. So the principle that we understand from this particular example is that we have two opposing views. One of coming from the scientific community and the other coming from a community that looks have the basis in economics and both view the same problem from very different perspectives. The

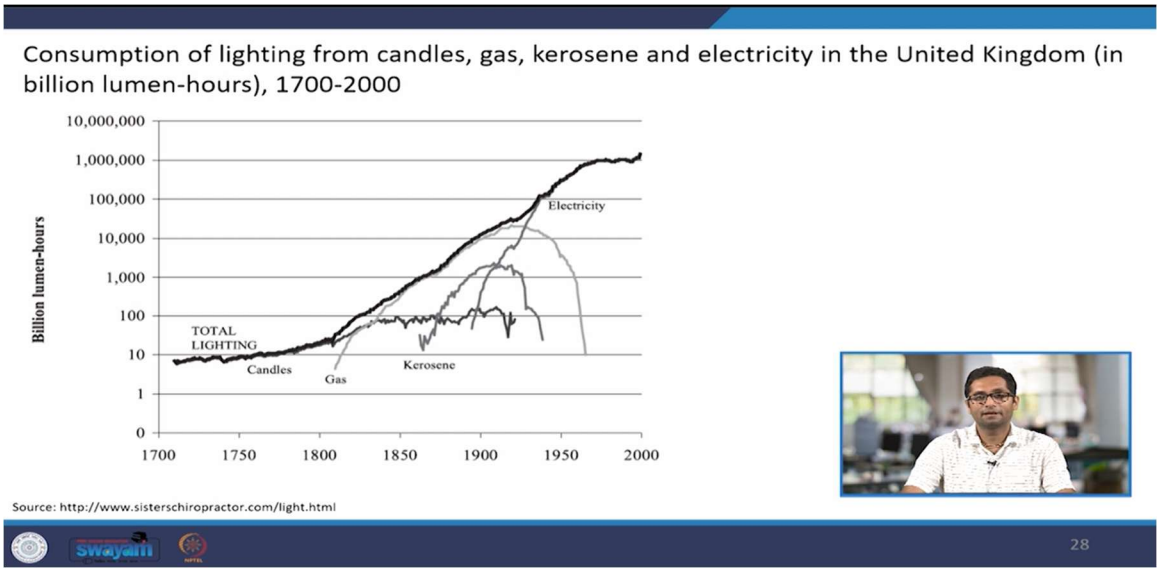
solution could have a learning from both of these perspectives. Of course we are going at a fast state of consumption but at the same time we also have to take in the social aspects or the behavioural aspects of the human society how it acts and how that would turn the systems into it. And this is something that is very important to understand as well as sustainability is concerned. Let us try to understand the same concept with the help of more examples.



So some of the examples where in the human ingenuity played a major role could be seen in three of these examples. So UK which is basically the birthplace of the industrial revolution has huge amount of wood consumption in the factories that was used for running the big big boilers as well as the production equipment.

And it so happened with time UK seemed to have a scarcity of wood. It did not have that much land to make up the wood that was needed. So it gradually shifted towards coal. First the inherent coal mines and then it started importing coal. As of today UK is a major energy producer and consumer but it works mainly on the imported coal which is available quite cheaply. So UK has been as a country has been changing the source of raw material. First it used to be wood then it was in-house coal and currently it is imported coal and now shifting to other sources of energy as well. Something similar is seen in the case of the crude oil deposits as well. There have been the cases of like we are going to see a peak in a particular year but that's not being happening because of newer and newer explorations. The places which were unexplored earlier such that in remote

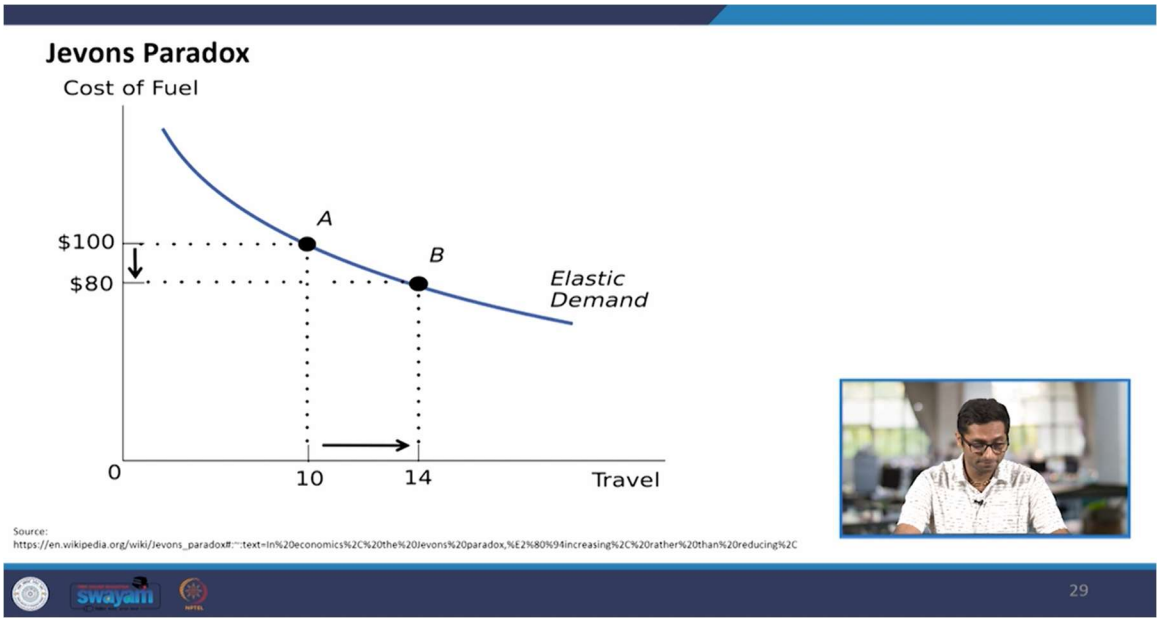
areas or inhospitable locations such as in the middle of the oceans are now being exploited and more and more crude could be generated. So we have been hearing stories that like the crude oil is going to run out fast but because of new and new explorations the betterment of technologies such a situation has not arrived so far. Something similar has been there in the case of fresh water as well. There have been concerns that the big big cities that we now have would soon run out of fresh water but because of the scientific progress there have been newer and newer technologies which have encouraged the production of more and more fresh waters and the rivers have been diverted. We have seen sea water desalination being carried out and the problems which were envisioned to be quite large or the problems that could be have been like predicted to be quite large today are no longer experienced because of the scientific knowledge that could have been generated or the scientific progress that have been made. So the human factor or the way societies have been able to adjust to some of the major problems is something that we cannot leave out when we are deciding on the sustainability of a particular pathway.



Another example that is worth discussing is the use of lightning indoor lightning by different countries. So here is a typical example for the case of United Kingdom or the UK. So we have seen that lightning is indeed one of the major players of the energy consumption and lightning is something that we have gone used to and it started with the use of candles in the early 1750s. This gave way to gas based lightning and as time proceeded there came kerosene based lamps, finally electricity based incandescent lamps,

CFL bulbs and finally we are in an era where we are using LED bulbs. So we see that the price of lightning has kept on reducing in the past and at the same time the efficiency of the process have been vastly improved.

So if we talk about the not so like past years earlier we were using incandescent lamps which were of the voltage of around 100 volt and the same amount of lightning can now be provided by LED lamps which consume almost 15 watts of electricity. But something that was coupled with increase in efficiency and decrease in price was also the increase in consumption of electricity or lightning needs. So irrespective of the price which is seemingly coming down and with respect to the efficiency which has greatly improved over the past 250 years or so, the total consumption of lightning has only been rising. The per capita use of lightning has again been rising and this gives rise to a rebound effect which is also called the G1's paradox which basically means because of a particular resource is available much more efficiently now and it is available cheaply the consumption of that particular resource has now increased. So in spite of the aim was like we would bring down the cost of electricity will bring down the efficiency of lamps so that the electricity consumption would increase as such that was not happening because the overall consumption lightning was increasing. Because people found it much more efficient to use lightning they are using overusing that particular product and this is called a rebound effect or the Jevon's paradox.

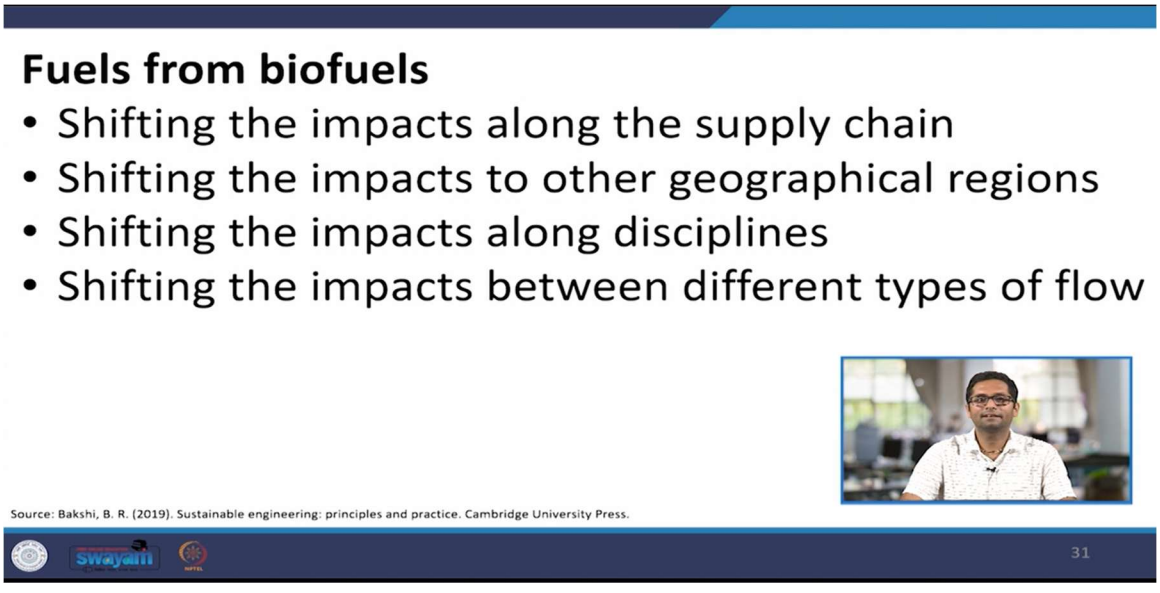


Another typical example that is normally being seen is that if we go for better roads that would or a road that is free from congestion that might bring down the cost of fuel that is used for a particular pathway that might not lead to lessening of the travel that would indeed increase the travel time by the people because people would want to travel more and more because of the new like spacious roads available and eventually that might lead to more consumption of fuel than that was initially thought to be have been saved because of the better facilities. So if you are providing in better facilities in terms of more efficiency better roads lesser cost that can have a totally different result as well because that also gives the perspective to the humans that they can keep on using that facility more and they would that can eventually lead to overconsumption and the type of energy reduction that was initially envisioned might not be achieved and something opposite might be achieved in terms of more energy consumption. And these are some aspects which basically calls for understanding the cross disciplinary nature of sustainability. It is not something that could be studied in silos as we have been doing in the earliest phases where like sustainability as such was not taught in any particular discipline. It is something that spans over different disciplines. It spans over economics, it spans over technology, it spans over human behavior.

Let us also try to see a typical example in the past with respect to the sustainable transportation. So here you see in two cases of the 5th Avenue New York City which is

one of the most affluent streets in the world. So you see the road in 1900s, you see all of the road is occupied by horse carts and there is just one car that you see in here that has been marked and a major problem that was encountered by that people in the city was that the roads were filled with horse dungs because the horses were living organisms and they need to evacuate themselves and the dung was normally spread on the roads and that had foul odor.

So that gave way to horse less buggies which was nothing but cars and we could see that there was a lot amount of disruption that happened in the transportation sector and 13 years down on the same street we see the whole road is filled with cars or horse less buggies and you can see there is just one horse buggy in here which even does not look like a horse cart but you can see like how the disruption happened in a quite a small amount of time. But this was not the only change that happened along with this of course the problem of horse dung spread around the cities was solved but a bigger problem came in that was of the smoke, the smoke that was formed because of the fumes of these vehicles. So people then went on for different cleaner fuels using catalytic converters and that gave way to even bigger problems in terms of energy consumption, the high rise of energy consumption and finally led to problems like climate change.



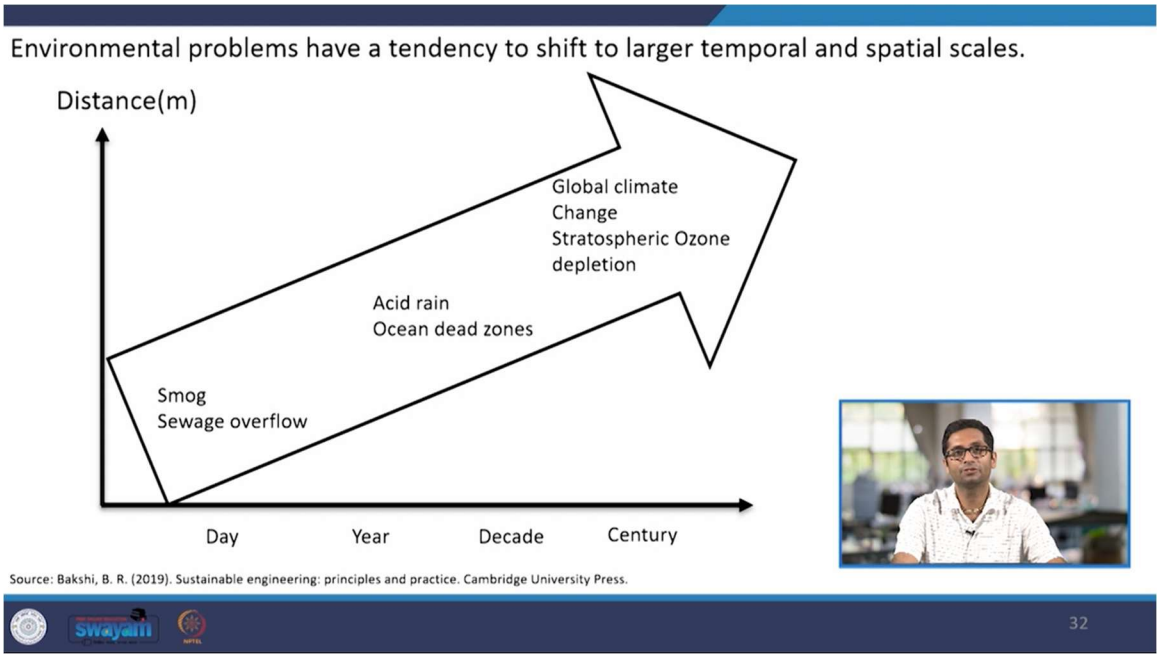
Further there is another example with respect to the biofuels. Biofuels in the past 20 to 30 years had a lot of emphasis being given in the countries like the US, Brazil and similar

countries where it was thought to be a cleaner and greener source of fuel but it also happened that it was found that the impacts were not being decreased but in fact the impacts were shifting to the supply chain, geographical regions, disciplines and the types of flow.

Let us try to understand with this particular example. So it was understood that of course biofuels when they consume they are only emitting the carbon that was intake and during the growth of biomass but what about the different kinds of fertilizers, insecticides, pesticides and the release of carbon during the storage that was not accounted. Eventually it was also found that many of the supply chain for biofuels and biomass had more amount of CO2 emissions as compared to the fossil fuel counterparts. It was also seen that in the cases of countries where rainforests were cleared for the production of biofuels that the impacts were transferred to the other geographical regions. Typical example is taken for the Amazon rainforest. A good amount of forests were cleared for the production of corn and different varieties of sugarcane for the production of bi-ethanol but it also led to the land use changes. The areas which are earlier acting as carbon sinks now released all the carbon although they were capturing some amount of CO2 in terms of growth of this corn or sugarcane but it was very less as compared to the carbon that was captured in the earlier areas. So if the total supply chain was captured in the entirety one would say that the carbon released from these kinds of land use changes were somewhat higher than the advantages that were derived. We also see that shifting towards biofuels also had an impact shifting towards the different disciplines and the growth of biomass on the land that was earlier dedicated for food production was now utilized for fuel production. This also led to the increase of the prices of the fuel or the corn that was used in the societies.

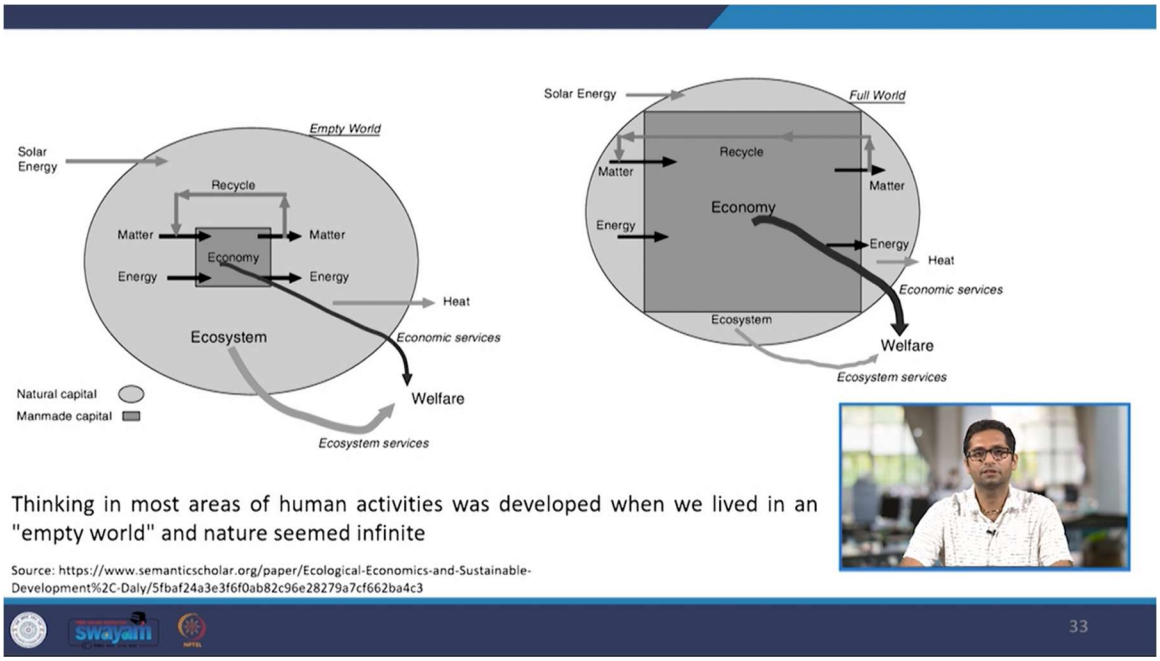
So we see that the impact, the economic impact could be felt by the other sections of the society. The people who were not very affluent had to pay the price of higher food prices. So that was another unexpected result. Another case that has been taken into account is the impact that was shifting between the different flows. Biofuels had a very high water consumption. Now with the aim of reducing the carbon footprint we had another major issue that was coming in in terms of the water consumption. Further the growth of good

amount of monoculture biomass also had an effect on the nitrogen cycles. Also there was huge amount of insecticides, fertilizers that was going in that also eventually led to increase in the eutrophication in the nearby water bodies. So that is again a typical example where you would be shifting the impacts into different types of flows. We cannot just take into account the CO2 emissions but we would have to take all the types of emissions, all the different types of flow together.



So just to give an example like if we see how this solutions have been changing in the past, first we were using the horse carts which had a small problem of cow dung and it was basically related to a small distance as well as some parts of the day. This gave birth to a better transportation in terms of the IC engine based vehicles which then produced smoke and other kinds of problems going all the way till acid rain and today we see the bigger problems of climate change as well as ozone depletion. So we have seen that because of the types of solutions that we have been coming across in the past we have only been increasing the temporal scale as well as the spatial scale of the problem that we have been producing. The solution that have been producing to earlier problem has only amplified the problem both on the spatial as well as the temporal axis. Earlier if you take the problem was small of the horse dung being limited to the cities as well as the problem persisted for a couple of days whereas the problems that we are facing now in the terms

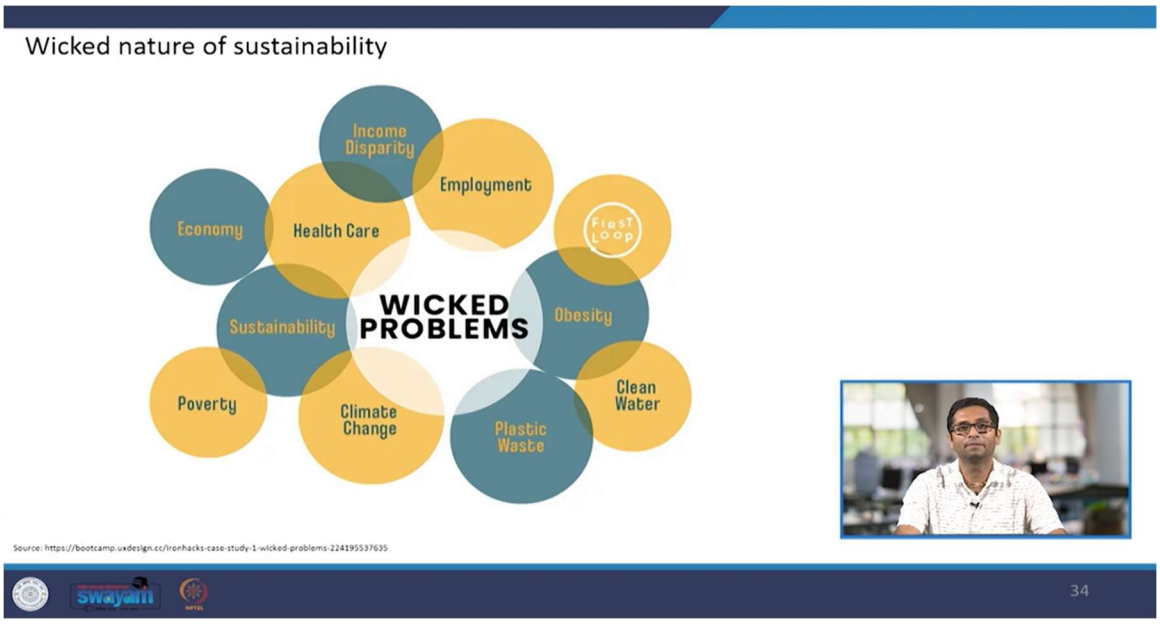
of climate change has the whole globe in its ambit and further this kind of problem will take centuries to get solved.



So again we also need to understand that how the understand the differences of how the technology has been developing in the past or the how various disciplines have developed in the past compared to today. So when the different disciplines of economics as well as technology was developing in a few centuries back the world was more of empty. We had huge amount of natural resources which were acting like an infinite sink for all the different kinds of emissions that were causing and also they were basically a source of all the different kinds of raw material that were used. We were never talking about the scarcity because the economic world was a very small part of the natural capital that we had. The resources were available quite abundantly the population of the world was quite small and a typical example could be like when we study thermodynamics we almost take like universe to be like an infinite sink.

Well that was true and also something similar is found in the economic theories as well. Compared to the world today the world is more full in the nature the economies have grown way more than it and every small decision that we make has a good amount of effect on the environment that we surround us. The environment no longer has the infinite capacity to absorb the different kinds of emissions that we create it no longer

again has the capacity to bring in the infinite amount of resources that we were planning to consume when these theories were developed. So most of the disciplines that were developed maybe a century or two centuries back had very different atmosphere around that around them when they were developed and that is quite different in the world today and this is something we need to understand when we are understanding or when we are trying to understand the concept of sustainability. It spans over different disciplines and further among the different disciplines we need to understand the assumptions that were taken during the formulation of the theories might not be equally applicable as of now.

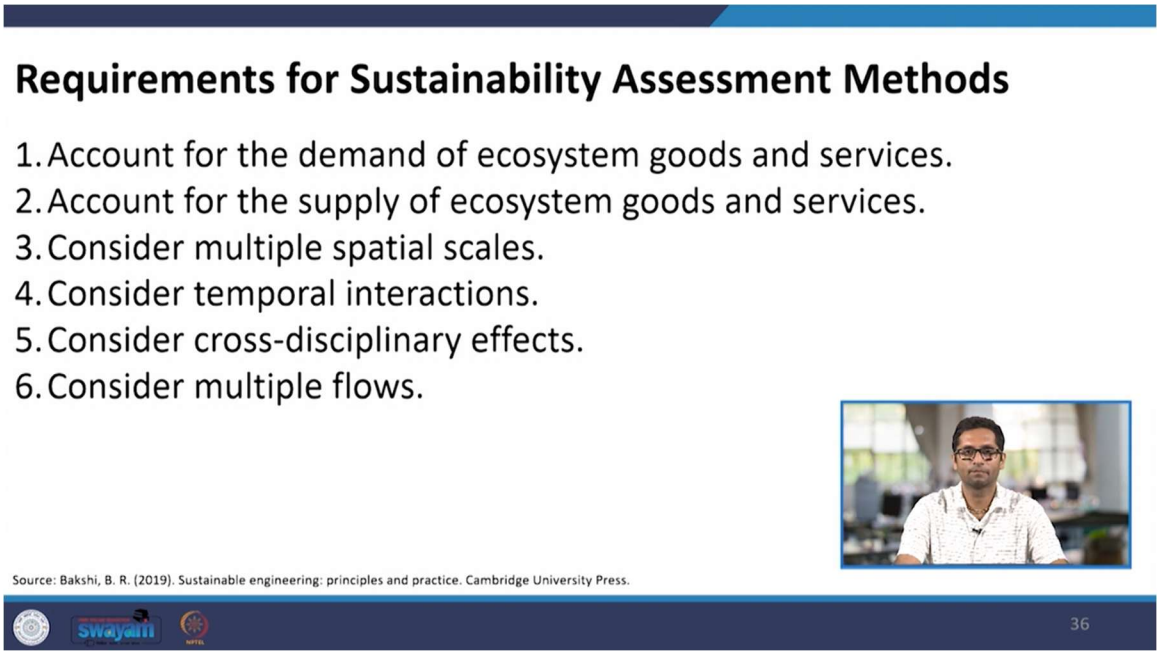


So sustainability is normally termed under the category of wicked problem. So what do I mean by wicked problem? So the normal problems that we encounter in science and technologies something like can we have a mission to the moon something similar to Chandrayaan or can we come up with a molecule that has so and so possibilities can we come up with a vaccine for so and so disease so these problems are termed under the category of the tame problems because we know like what is the pathway that has to be adopted and we also know how to judge if the particular solution is working or not. We know the pathway to be adopted but could be the different permutation and combination and finally we know if the particular solution is working or not. Compare that to these typical problems in science and technology sustainability is termed as a wicked problem there is no one solution every one of us can have a very different definition of

sustainability one solution that might be sustainable for me or in my perspective might not be sustainable in your perspective I might be giving more emphasis to the economic value of product you might be giving more emphasis to the carbon footprint of a product a third person might give more emphasis to the social acceptability of that product and in such a case all the three of us will come to a different solution and this is what it means by wicked problem. A wicked problem is something that does not have one answer one commonly accepted answer that could be filling all the criteria further a similar problem could be pursuit of happiness we all have our different definitions for happiness something that makes me happy might be a cause of sorrow for you and vice versa.

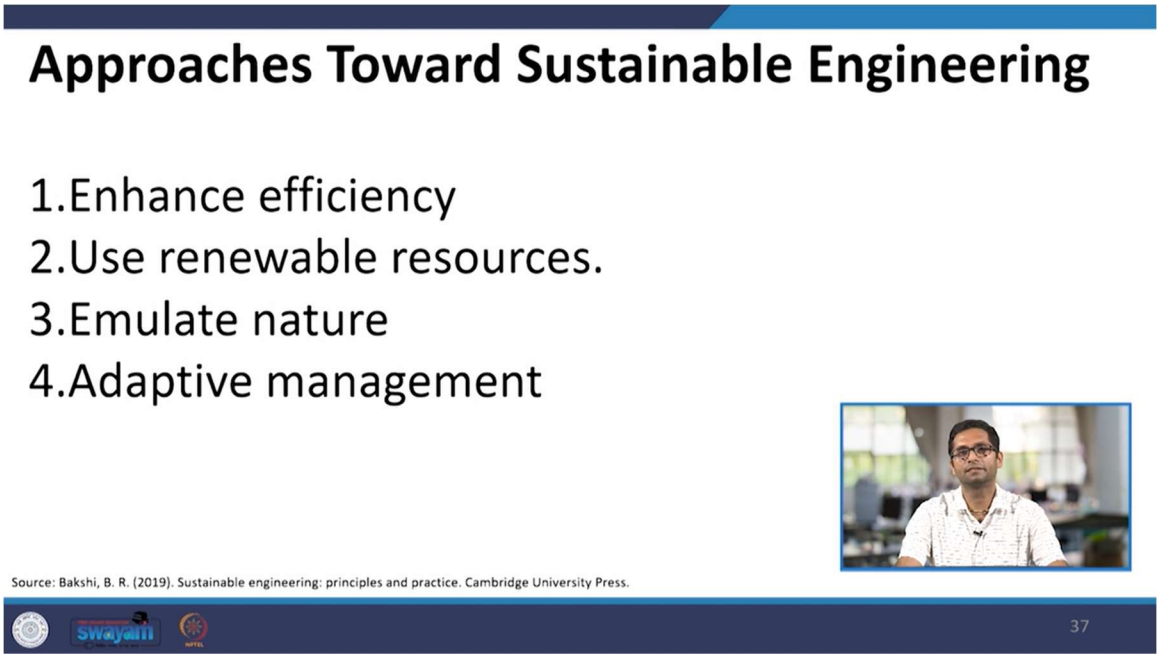
Another typical problem could be the raising of kids some of you might have that experience there are some of the choices that we make in and that could have very different products in the type or in the way we are implementing those decisions and these decisions can only be seen in the background as of today it is very difficult to for me to say a particular solution or a pathway is sustainable it is only in the hindsight when I look back I can say this was truly sustainable and not and this is where the problem lies. The definition of sustainability of course we all understand but the quantification of sustainability is very difficult to define mathematically in terms of number because all of us would have our own definitions associated with it.

So again we need to understand that sustainability is not just about the environment but it also takes into account the societal and economic aspects. Therefore for a system to be truly sustainable it is imperative that it operates within the ecological limits it does not have a very high like consequences or very large consequences on the environment it should be acceptable to the society at large and it should also contribute to the economic prosperity. If any one of these three is not met probably we are losing on the sustainable aspects and a fourth thing that is also often missed needs to be added that sustainable system must not demand from the ecosystems that can be supplied without transgressing the critical threshold. It should not happen that we are spoiling the equilibrium in the nature that has been existing for many centuries.



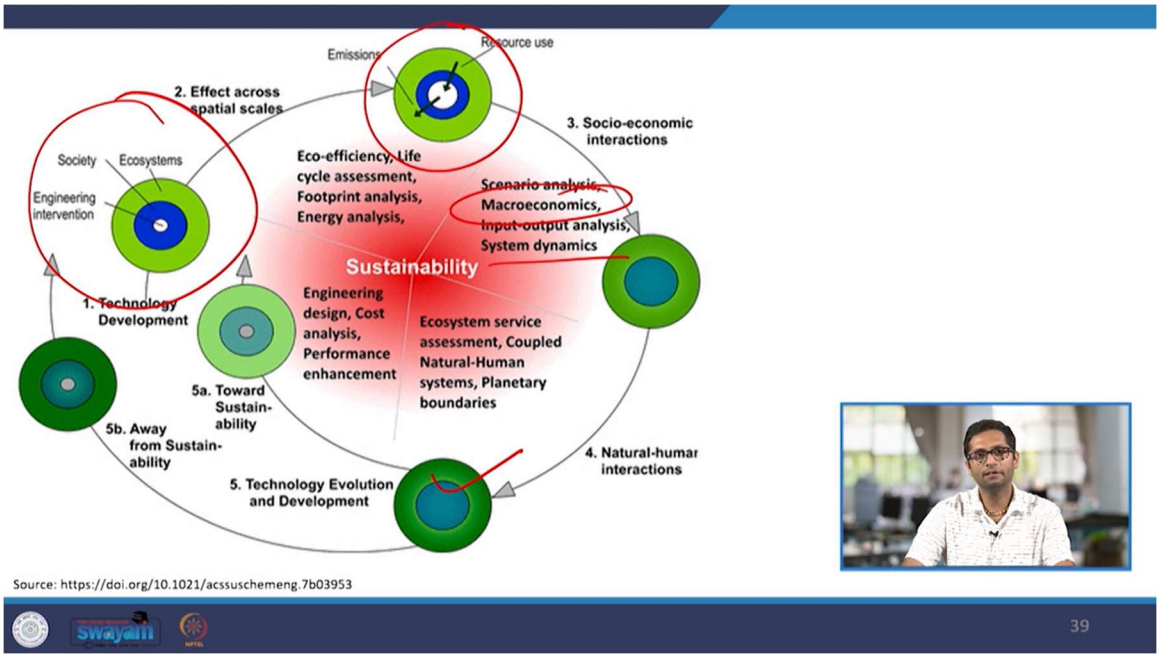
There have been many sustainability assessment methods that are available in different disciplines and we will be discussing just one of them in the future classes but to discuss like for a good sustainability assessment method it needs to fulfill these following criterias. It needs to account for the demand of the ecosystem goods and services. It should be able to see that what are the different kinds of minerals or the services that we are taking from the ecosystems or the environment. It should also be able to account for the supply of ecosystem services in terms of its ability to take in different kinds of emissions.

It should be able to consider a different spatial scales. It should be able to see how the technology or how the changes will be taken if I apply a solution to maybe a city or a state or a country. It should also have certain ability to consider different temporal interaction. It is expected that with the advent or with the coming forth of time there would be a technology improvement and this technology improvement can have other consequences. It should also consider the cross disciplinary effects. We have been discussing the G1's paradox or the rebound effect. It should not happen that in the way of making something very efficient it might lead to the over consumption of a particular energy source. And further it should pay emphasis to the different flows that are coming from that particular pathway. It should note that we should just keep freezing ourselves with the CO2 emissions. We need to also account for the water footprint, the land footprint, the emissions that lead to the ozone depletion, the emission that might lead to human toxicity. So it should not happen that we pay more emphasis to one leaving behind the others.



And if I talk about the different approaches towards sustainable engineering that have been adopted, so four come to the forefront. One is the increasing of the efficiency. We need to increase the efficiency of processes as much as possible. Second is we want to use much of the renewable sources because as compared to the fossil fuels, the problems

associated with renewables are quite smaller as we have discussed in the previous classes. Further, we should also pay emphasis to emulating natures. We should include nature as far as possible in the solutions that we derive. More and more emphasis is now given to nature based solutions. The solutions which are able to replicate the nature's ability to adopt and behave and that is something that is expected to provide a sustainable solution to the problems that we are encountering. And finally is the adoptive management wherein most of the solutions that we would be deriving might be aiming to achieve a steady state in the future. But such a steady state is very difficult to achieve. In most of the cases, the system would be much more dynamic, much more prone to disturbances. So we should be aiming for a much more resilient system that is able to rebound back in case there is any problem that is encountered and much more of an adoptive system is something that we should be aiming for if you are looking for sustainable pathways.



Further, if we talk about the different kinds of technologies or matrices or ways that have been proposed for quantifying sustainability, there are quite a lot. So it starts with the scientific intervention which we see in the technology development pathway. So there is a new invention that is having its interaction with the society and the ecosystems. First thing is we would want to see its effect on the spatial scales. If we increase the scale from the lab to the city or to the industry, what is going to the scale? And for that, we would

like to take an analysis like life cycle assessment, footprint analysis, exergy analysis, eco-efficiency. Once that is established, we would want to also understand the socioeconomic interactions. How would economics play a role in the future inclusion of that particular pathway or that particular invention? And for that, we would like to adopt macro analysis, input-output analysis, system dynamic analysis. And once that is established, we would want to go to understand the natural human interactions to see if there are any rebound effects or there are any surprises above the energy ladder. And for that, we might want to take an ecosystem services assessment, natural human systems, planetary boundaries, and there are a lot of types of methodologies that have been suggested. And once we have reached at that level, we can say that like whether the system is going towards a sustainable pathway, which is basically able to go back to the original from where we started or it is going more towards a linear pathway, which is more unsustainable in nature. And this is just to give an understanding that there are many types of matrices, many types of methodologies that have been proposed in the past or are currently being used. And they are looking at the different types of interactions. And we will be discussing one particular type of path, one particular path of determining sustainability that is called life cycle assessment in the future few classes that is basically wanting to determine like what would happen if I increase the spatial scale of a particular technology. So with this, we have tried to understand the different types or we have tried to understand the concept of sustainability and the different types of notations attached to it.

We have also tried to understand what we mean by the wicked nature of sustainability, the different types of methodologies adopted to understand the sustainability and like how difficult is to determine whether a product is or the service or the pathway is really sustainable or not. And carrying on forward with discussion, we will be trying to understand one particular type of methodology which is called life cycle assessment in the future. With this, we end today's class. Thank you.