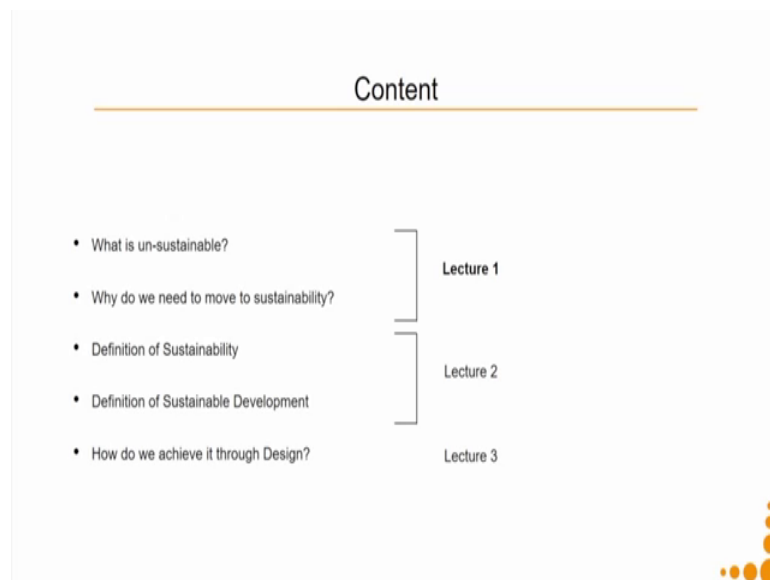


System Design for Sustainability
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Module - 01
Lecture - 01
Sustainability and Sustainable Development

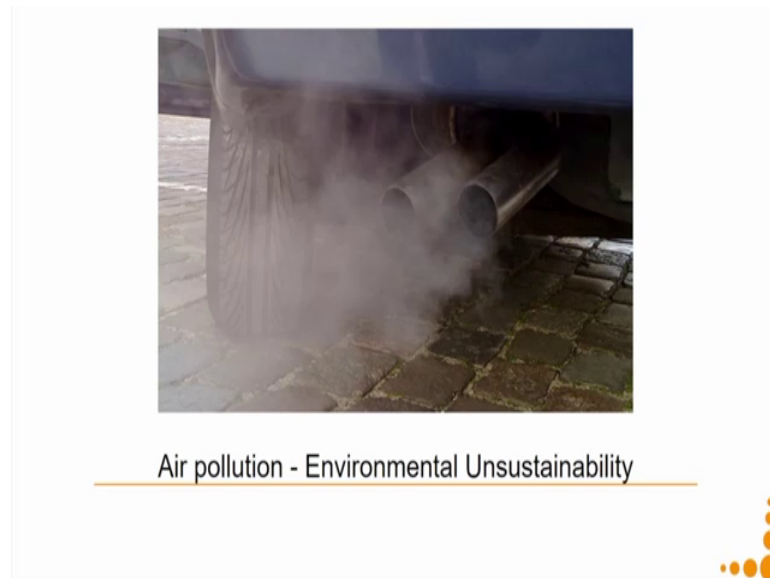
Hello everyone, welcome to the 1st lecture for the course Design for Sustainability. So, the course will be divided into couple of modules; and each module we will discuss certain contents.

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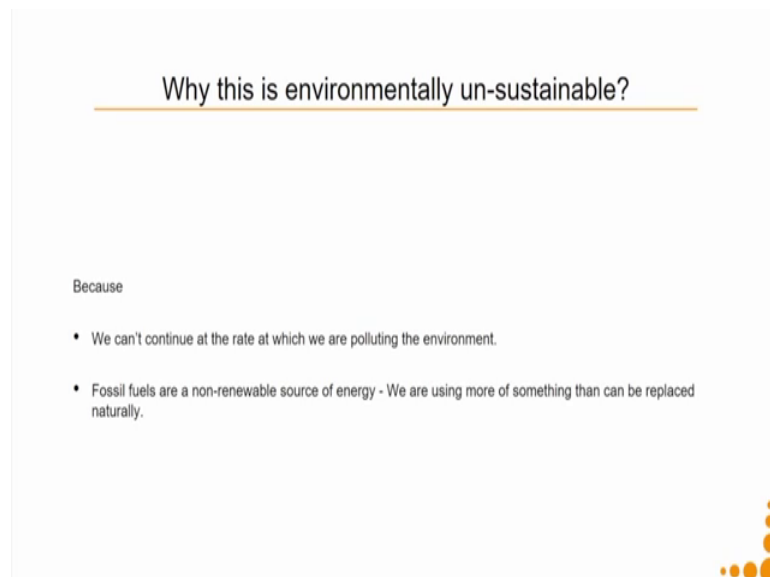
So, in this first module what we are going to discuss is; what is un-sustainability. So, before trying to understand what sustainability is, it is very important to understand what are the un-sustainabilities, and why do we actually need to move towards sustainability. In the next lecture, we will discuss about definition of sustainability and that of sustainable development. There after the 3rd lecture of this module will consist of on how do we achieve this through design? So, coming to the first topic, what is un-sustainable?

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Let us discuss this through some examples. So, all of us regard this as a very unsustainable solution. Because, these fossil fuel run vehicles, they emit lot of air pollution, which is damaging to the environment, it also causes as many different health hazards.

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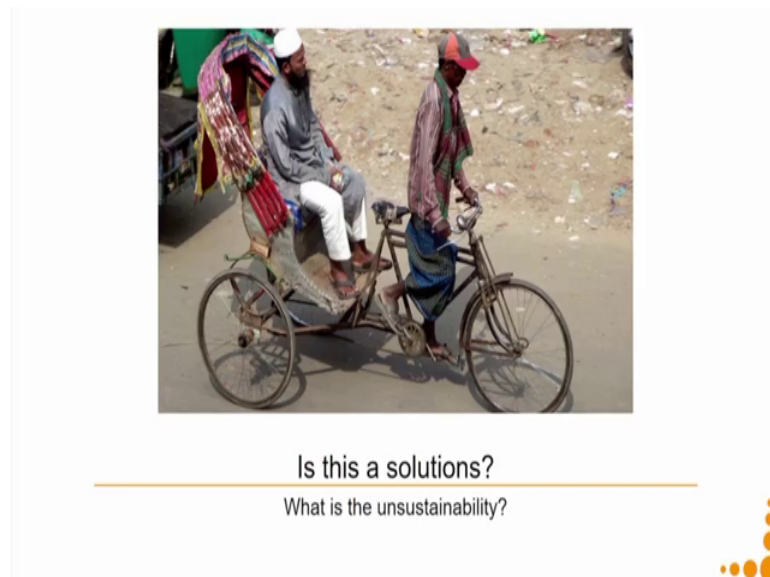


Why do we call this particular solution as un-sustainable? There are two reasons. Reason one we cannot continue at the rate at which we are polluting the environment at this point of time. It is causing more and more health hazards, so we cannot continue at the rate at which we are polluting the environment. Secondly, fossil fuels, these vehicles are

run on fossil fuels; fossil fuels are a non-renewable source of energy. So, we are using them at a rate much faster than what it can be naturally replenished. So, we are using more of something than can be replaced naturally. So, something becomes unsustainable, then we are not going to be able to continue at the rate at which we are doing it right now.

Now, let us look at some other examples of transportation. Before going into the other examples, let us go back to our previous example, cars are a really good innovation; it can move us from point A to point B. And the distance between point A and point B quite be pretty large, we cannot dispense our activity of moving from point A to point B.

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Now, coming to this another solution of transportation, this can also move us from point A to point B. Yes, for sure the point A to point B cannot be very far away, they have to be pretty near to each other. When someone is operating the cycle rickshaw, there is no pollution happening, because this runs on a human beings power, it does not run on any kind of fossil fuel or any other source of energy. So, environmentally it is non-polluting, while it is in the operational phase. I am not talking about the manufacturing phase of this cycle rickshaw, I am only talking about the phase in which we are using it. So, it is environmentally sustainable.

But, now tell me as a consumer, you cannot use this from travelling for 10 kilometres. So, is this a solution which is environmentally sustainable, a good solution for me as a

consumer, I do not think so. Of course, for short distances it is, but not for large distances, it cannot replace cars. Now, think about this cycle rickshaw puller, is it a very economical solution for him? Is it a very comfortable way of earning money? So, I am trying to talk about is the social sustainability of this rickshaw puller, the economy sustainability of this rickshaw puller. So although, a transportation medium as a cycle rickshaw is very sustainable environmentally, but that does not ensure that it will be socially and economically sustainable.

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Another transportation medium, again this cannot take us over large distances. Yes, in cold countries or in countries with more flat roads. This can be a means of transportation which can be used for much larger distances as compared to what it can be used in climate like ours, which is hot. So, now what is the problem, this is again a very environmental friendly solution.

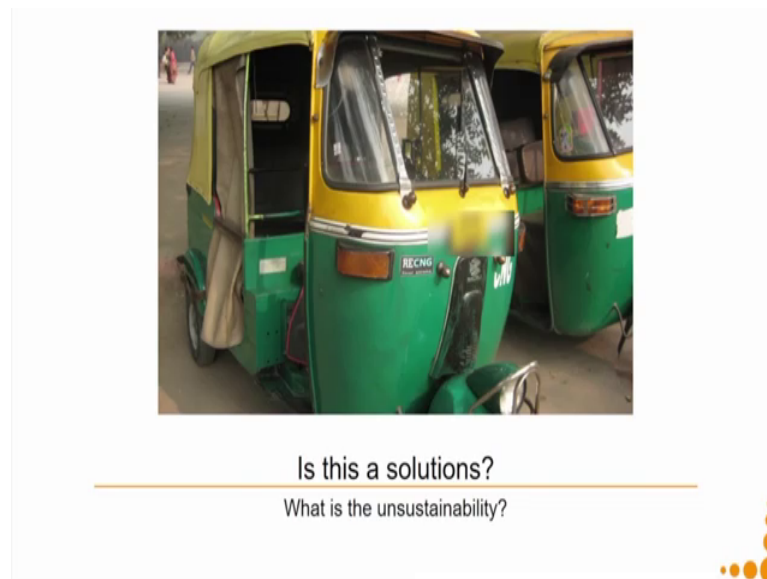
So, the bicycle sharing system that I am showing you is system it is called as big c cycle sharing system, it is from Montreal. So, I am not talking specifically in terms of this cycle solution, but in general any bicycle sharing system like this. So, environmentally very sustainable solution, also I am not owning this bicycle. So, each one of us if we try to own bicycle we are consuming lot of materials, which are used to make this bicycle.

Now, this is a shared system. So, I do not own. So, lesser number of bicycles will be required to serve a particular size of population than in case everybody has to own a

bicycle. So, environmentally sustainable while running it, environmentally also less polluting, because it is a sharing system.

Now, as I spoke in a hot climate, will you be able to ride it? So, it might not be a very acceptable solution. Now, imagine riding this bicycle on our city roads, which are extremely polluted. And you are exposed to this pollution for such a long, long time, will you want to do it or will I say that it is a healthy option to do it. What happens to our traffic situation, all of us know that our traffic situation on the roads is pretty bad? So, in such traffic situation is it even safe to ride these bicycles, given the fact that we do not have dedicated bicycle needs on our roads. So, not necessarily something which is environmentally sustainable is sustainable, because it might not be socially sustainable, it might not be economically sustainable.

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Now, coming to this particular method of transportation, the CNG run auto rickshaws. So, they can take you for a long distance, so the long distance travel problem is resolved. Because, when CNG vehicles are running, they do not emit any visible smoke. So, it was assumed that they are a very clean source of energy for running vehicles. So, a large number of our city is went towards mandating that all public transportation, which is like city buses as well as auto rickshaws be run using CNG. Of course, because you are not seeing any smoke coming out of it. There is no not much apparent social and economic troubles also associated with this kind of transportation.

But, more recently CSIR labs of the country figured out that when you are running a CNG vehicle, it releases carbon nanoparticles. Now, these carbon nanoparticles you cannot see them, but they are a big time carcinogenics. So, a solution which might seem to be sustainable at a given point of time, at a later point of time you might figure out that it is not so sustainable, just because your technological knowhow regarding that particular technology improved. So, we will discuss more about this particular aspect of un-sustainability, in the next lecture coming up.

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Coming to this another mode of transportation metros, runs on electricity. So, of course, they do not emit any pollution while they are running, because they using electricity. They can also carry a large number of people over a large distance; they also make our cities less traffic congested. Great solution, but how is this electricity produced in our country, it is produced by burning coal in our thermal power stations.

And when you we burn coal, we are producing lot of pollution; or otherwise you can construct hydroelectric projects, so where (Refer Time: 08:59) big dams and produce this electricity. Dams change the local ecology of the place, in many places floods or draughts are being blamed upon the construct large-scale construction of dams, it also displaces lots and lots of people. So, you can see that hydropower plants have environmental problems, social problems as well as economic problems, when we speak in terms of sustainability.

What do we gathered from here, so it is not only the product at the usage phase, when we are talking about sustainability, we have to consider the entire life cycle of a product or a service. What do I mean by an entire life cycle is starting from the raw material extraction, so say for example, for making this train body, I might need steel, I might need aluminium, I might need different kinds of plastic, and. so on. So, I would need to extract these raw materials. So, what are the in sustainabilities or un-sustainabilities involved, when I am extracting these raw material that is my stage one.

Second stages I will put all these raw materials together and make this final product, so which the production phase. The third phase is when from this place where this train has been made, I have to transport it to the place where it will be finally used which is the distribution in a phase. So, all the sustainabilities and un-sustainabilities involved during the distribution phase, then comes the usage phase.

And finally, when this train is no longer useful, either I will have to scrap it or recycle some parts of it to make use of it for something else, so that is the end of life stage. So, whenever I am talking about sustainability, I have to consider a particular product or service across its entire life cycle, so that I can clearly say whether it is sustainable or un-sustainable, and what are the point is at which it is un-sustainable.

I will give few more examples to explain you, when it is the usage phase, which is the most polluting. And when it is the production phase, which is most polluting. Say for example, in this case of this metro train, the amount of energy is spent the amount of pollution caused during the time it is manufactured is very much more lower than during its usage phase, because this train might have a usage time spread over around 20 to 30 years. So, the impact at the usage phase is very much larger than it is at the manufacturing phase.

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Consider this other means of transportation. This is the means of transportation, which runs from solar energy, great solution, because it is solar energy. So, once my solar panels are on, they are virtually costing me nothing to produce energy and run this vehicle. This vehicle of course, does not have any emission, because it is running on solar energy. But what happens to the battery, due to the current battery technology, the current battery technology is not environmentally friendly. So, although the energy source in this case was very environment friendly, but the battery is making a un-sustainable at a certain point of time.

So, in a previous slide, we were discussing about considering a product or service over its entire life cycle, and analysing the sustainabilities and un-sustainabilities at various stages. And what we are talking about in this particular slide is it is not only about the life stages, but it is also about the different components that are going into a particular product. So, some of the components might have a problem, and we would require to redesign those components, so that we can achieve better sustainabilities.

Also from these examples, what you can see is sustainability is not an absolute concept. So, none of these vehicles are actually truly sustainable. So, one might be more sustainable than the other in a given context, say a bicycling might be a very sustainable solution as compared to other means of transportation, when I have to travel across a small distance.

Similarly, a metro might come out to be a more sustainable solution, when I have to travel over a large distance, and I can carry a large number of people together: so my impact which is being caused, because of this metro is distributed over a large usage period and over a large number of people, which means large number of use cases. So, most of the times you will see advertisements with say this is a very eco-friendly product, it is not a right statement to make nothing is absolutely eco friendly or absolutely sustainable, it is only more eco-friendly or sustainable than other competing solution in a given context. I will explain this better with these three examples.

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So, the first is earthen pot; it is made by baking clay wet clay pots. The white product that you see on the so, this white product that you see over here is a paper cup; again it is a disposable paper cup, so that your hot coffee or tea does not crumble the paper cup. Inside the paper cup I have a, so on this particular surface, I have a lining of a very thin lining of plastic. Coming to this particular solution, these are again disposable plastic cups.

Common sense says that the first solution that is the cooler or the earthen pot is the more sustainable solution or the most eco-friendly solution. This is the complete myth is a misunderstanding of the whole concept of eco friendliness or sustainability. Why? So, as soon as you bake clay, bake clay is ceramic, it is no longer clay. So, you can break it down into smaller and smaller pieces, and those you can also make it into a powder, but

that is still ceramic, it is not clay. So, it is not biodegradable no crops can grow in that particular powder. That is why, we can unearth earthen pots from as olden times as the Harappan culture, because they do not biodegrade.

So, when you make a earthen pot for drinking tea once, all of us know that we might be using this earthen pot only for 2 to 3 minutes till I finish my tea. So, for making this earthen pot, which is non-biodegradable I have to burn this pot to create these bed clay pot, and I am using biomass to burn these clay pots.

So, just imagine the amount of biomass I burned, the amount of pollution that I create for this very small one time usage of couple of minutes for this particular cup: if this cup was not meant to be disposable, but if I bring this cup home, and I am going to drink tea or coffee out of it again and again. In that case, the un-sustainability is in the manufacturing phase still remain, it is we are still burning biomass, we are still creating lot of pollution. But the pollution created over their gets distributed over many usages, when I am using it at home for many times.

So, my ultimate impact goes down. Of course, impact is not zero, but impact can go down. But, when I am using it in a scenario like offering tea in railway stations or such kind of a context, this is a completely environmentally unfriendly solution to go ahead with.

Now, coming to the paper cup with the plastic lining, again a disposable cup, this cup can be used for serving tea and coffee in railway stations or other such context, because of the plastic lining inside it I cannot send this paper cup to a paper recycling facility. Because, there is no way, I can remove that plastic layer from the paper

So, this has to go into a landfill. Under the right kind of such conditions after a few months, the paper will biodegrade, and the plastic will still remain, because it is a very very thin film of plastic. I will have this thin film of plastic lying in the environment for a very very long time, and it will degrade after that which this time runs into couple of 1000 years.

So, you can see in this particular case, the paper cup with the plastic I cannot use them at home or in any of situation where I can keep on reusing them, because the nature of the material does not allow that kind of a usage, it can be used only once. And then, if you

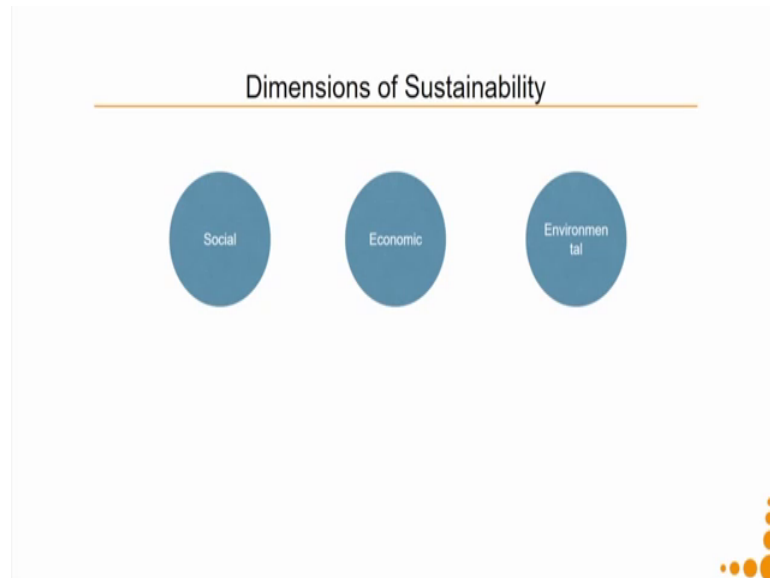
pour more and more hot coffee or tea after a point of time, it will start leaking.

Now, coming to the third solution, which is a purely plastic cup; and it is a disposable plastic cup. The problem again lies over here this is lot of plastic biomass as compared to the previous solution, where I had a very thin film of plastic. This plastic when goes to a landfill, it will take this extremely long period of 1000 of years to degrade in the landfill. This plastic cup if we have a way in which I can collect them back, clean them, dry them, I can again pulverise them, and use that particular plastic for other purposes. This plastic can no longer use for food grade purposes, but it can be used for other kinds of purposes. But that is only possible, if I have a collection system, otherwise not.

So, from these three examples, you can see that sustainability as a concept, so none of these solutions is absolutely sustainable. All of these solutions have relative degree of un-sustainabilities, depending on the kind of usage scenario that I put them up. Now, tell me I can also replace these cups with say steel cup or a glass cup, and serve tea in this railway stations or such kind of situations. In that particular case, I might have to consider that; what is the amount of pollution I am causing, because of the detergent and water that is required for cleaning them after each use.

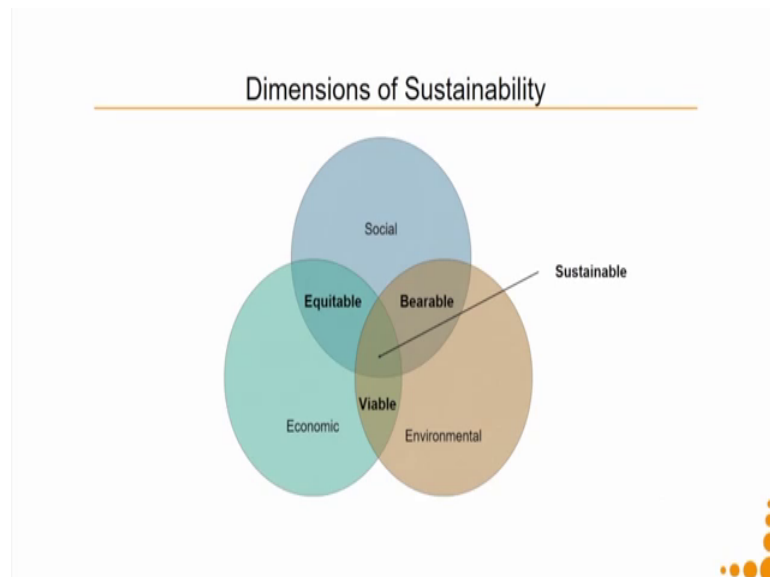
But tell me, although that is a very sustainable solution. Imagine a tea vendor, who has to travel along the Indian railways from one coach to another selling tea, will this person be ready to carry all these reusable cups, made up of say steel or glass or ceramic and serve tea. Because, now this person once goes serving tea, then has to come back, collect all these cups, the wait involved is also pretty much high. There is also chances that there people might steal them, people might break them, so the person might end up losing lot of these cups also. So, do you think although that might be a more environmentally friendly solution, will people want to accept that more sustainable solution, the vendor will that person accept, will it be economically sustainable for that person to take that solution; maybe not.

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So, from these discussions we can see that whenever we are talking about sustainability, sustainability is to be seen not only on the environment environmental dimension. We have to look at sustainability from the social, economic, as well as the environmental dimension. So, how does it go ahead?

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So, say for example, something is socially sustainable and economically sustainable, we call it as a equitable solution; something which is socially sustainable and environmentally sustainable, we call it as a bearable solution; something which is

economically sustainable and environmentally sustainable, we call it as a viable solution. Only when something is sustainable on social, economic, and environmental aspects all the three aspects, we call it as a sustainable solution.

So, I will give you some examples, which will make it more clear. So, for example, growing crops using chemical fertilisers and pesticides, have given rise to a bumper crop production. So, you must be aware of the green revolution that happen in our country. So, usage of fertilisers, pesticides, machinery for doing farming help to increase the farm output in our country to a large extent. As a result, we could achieve food security.

So, we could so, since we achieve food security, we could give farmers better income. So, we had got a socially good it is a socially sustainable solution, it is an economically sustainable solution. But, fertilisers and pesticides all of us have caused lot of environmental damages. So, it was not environmentally sustainable at that point of time. So, it was an equitable solution, because it was a socially sustainable and economically sustainable solution.

Now, over the decades, when we have kept on practising agriculture using these environmentally challenging method like fertilizers, pesticides, machinery, pumping out lot of water from the underground. Our rivers also have got polluted, our food is polluted, which is causing us lot of health hazards; our soil fertility has reduced. The water level has reduced so drastically that have to spend so much more money to draw water. So, it is estimated that around due to these environmental damages, which has been which has occurred since the last couple of deep decades.

The input cost of growing 1 kg of rice has increased from somewhere between 20 rupees to 30 rupees per kg. So, now you can see there is a reverse impact, because of this environmental un-sustainability. There are lot of farmers, whose who are going into debts, because if in because input costs are higher, so they have to take loans to farm their farms. If the crop fills, then they have lot of debts. So, there is economic un-sustainability. Also it has because of the bad impact on the health of eating those kind of food or even the bad impact due to the change in the social fabric of the agronomic societies, there is lot of social un-sustainability is which are coming up.

So, since this solution was at the equitable stage that is socially and economically sustainable and was not environmentally sustainable, we can see that there is a backfire

which is happening, the economic and social sustainability is also now getting damaged. Now, let us consider another example, say organic farming is good for the environment; and for the health of the consumers. So, I can say it is socially sustainable, it is environmentally sustainable. So, it is a bearable solution.

Now, the current ways of producing by using organic farming techniques, the production volumes are relatively lower. So, its supply of food grains reduces in the market, and the demand stage high, because of because of population remains the same. So, the price of products will go very high. So, there will not be economic sustainability, which will in turn damage our social and environmental sustainability eventually.

Say for example, services like Uber, they are very economical alternative to go over long distances. They are also economical in the sense that I do not need to purchase a car; I do not need to have a space to keep that car in my house or in my office, parking space is expensive. Whenever, I need a car, I can book a car. So, economically it is a great solution. Environmentally I would say it is a great solution of course, because if I personally by a car and I use that car only for an hour or two in a day that huge amount of material that has been consumed for my car lies an use for most part of the day.

But if it is a system like Uber, the car gets more and more used. I also produce lesser number of cars I have less traffic congestions, because I have lesser number of cars in the road. So, environmentally also it is a good solution as compared to owning cars. You will see it is always like better solution as compared to something else nothing is like best solution.

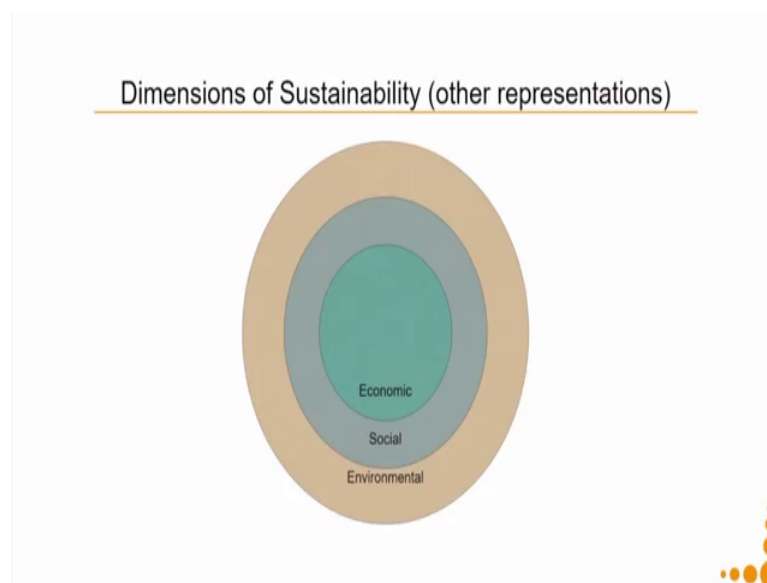
But there are lot of protest going on by different groups, in different parts of the world against Uber. Why these protests, these Uber drivers are not owned by the; they are not the employees of the company, the nature of the contract that they have with the company, the drivers realise that they do not have much social security out of this particular job. So, they are demanding more social security out of the job. So, this is an example, where I have a economically sustainable solution and environmentally sustainable solution, which is like a viable solution. But, because of the social unsustainability, it might disrupt the solution in a longer run, if it has to continue in this particular fashion.

Hence, sustainability is always achieved only at the confluence of these three dimensions

that is social, economic, and environmental. This particular diagram, which I am showing you it might be misleading that the contribution of all these three dimensions is equal, but that is not the case. Depending on a context, one particular dimension might have a very much more bigger impact than the other dimension.

So, when we go into our next modules, the module on product service system design. We will talk more about how do we assign different weightages to different dimensions, depending on the design context in hand.

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There are many other representations of these dimensions of sustainability. So, if you see this particular representation what this representation means that the economic dimension is that the core, then comes the social dimension, then comes the environmental dimension. So, your economic sustainability has the biggest importance which is encompassed by the social dimension, and thereafter by the environmental dimension.

Usually it has been seen that if a solution is not economically viable, it becomes unacceptable for people for a long run. Governments or charities might fund them for fund such initiative for certain period of time, but it cannot be long run at a long for a long period of time

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Another reason, why we have un-sustainabilities is about consumption pattern. For example, the air conditioners from past decades, used consume lot of energy. So, the running cost of air conditioners used to be very high. So, lesser and lesser people were interested in buying air conditioners, because the running cost of an air conditioner is very high

Now, the industry has moved towards star rated electronic products. So, I can buy a five star rated air conditioner, the initial cost might be higher than buying a three star rated air conditioner, but the running costs are very much more lower. Even a three star air conditioner of today, consumes very much lesser energy than what used to be couple of decades back

Now, this is agreed environmental sustainability brought in that the industries move towards making more energies efficient air conditioners. So, we brought in sustainability on the production side. Now, sustainability on the production side what it had an impact on the consumption side, now since my recurring expenditure on air conditioners reduced, more and more people went ahead and bought air conditioners. So, the number of air conditioners working in the whole world increased exponentially.

So, the amount of energy that I might have saved, because my machine became more environmental friendly that is being offsetted, because the number of machines have increased a lot. So, many at times it has been observed that if the industry moves towards

more efficient production processes that does not imply that you will get real sustainability impact, it is more about the consumption pattern. So, if we consume more if we keep on consuming more, even if a machines are very efficient, we still bring in lots of un-sustainabilities.

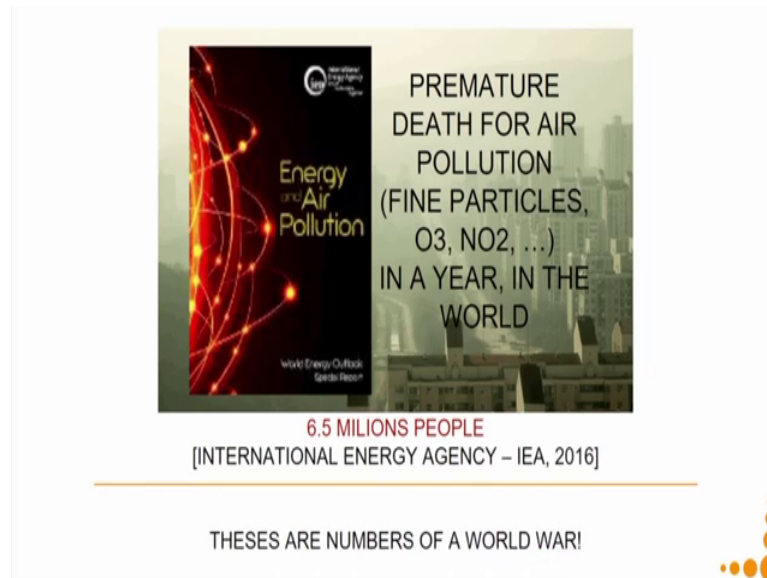
Now, coming to the next topic of today's lecture is why do we need to move towards sustainability? What is that? That is compelling us or it compels you all, who are the future designers and engineers to learn about sustainability to practice sustainability in all their design activities.

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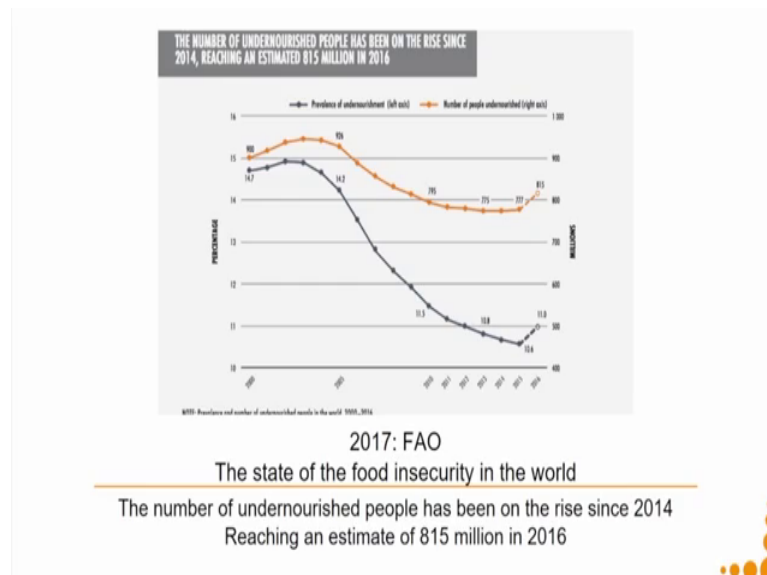
So, research shows you can see the first image versus the second image, it shows the sea ice extension decrease from 1980 to 2012. We keep on hearing about this increase in level of the sea, and the melting of the polar ice caps in news every now. And then, so the sea level increases expected to be around 0.8 meters, which means a large part of our globe will be under the sea. So, our habitat is gone.

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A report on energy and air pollution, it tells us that every year 6.5 million people die, because of all sorts of air pollution which might be caused by fine particles, ozone knocks and so on. Just imagine 6.5 million people, these were the numbers which you would we were losing during world wars.

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FAO is Food and Agriculture Organisation; they do a lot of research on the food and agriculture scenario of in the globe. According to their research from 2014 onwards, the number of undernourished people in the globe is on the rise, which means they are

having lesser food production.

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This is another research, which says if you if all of us on this earth were supposed to live the way Australians live, we would require 5.2 earths. If we were to live like if all of us were to live like people living in USA, we would require 5 earths. So, if you go down the last one is India, it says if we all live like Indians live, we would require 0.6 earths. For the global thing is like the currently the way all of us are living, we require 1.7 earths. So, the amount of material energy that we are consuming we require 1.7 earth, of course we do not have that extra 0.7 earth.

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Sustainability: Size of Change

by 2050 production & consumption systems in industrialised contexts should use

~ 90% LESS RESOURCES

than they are doing today

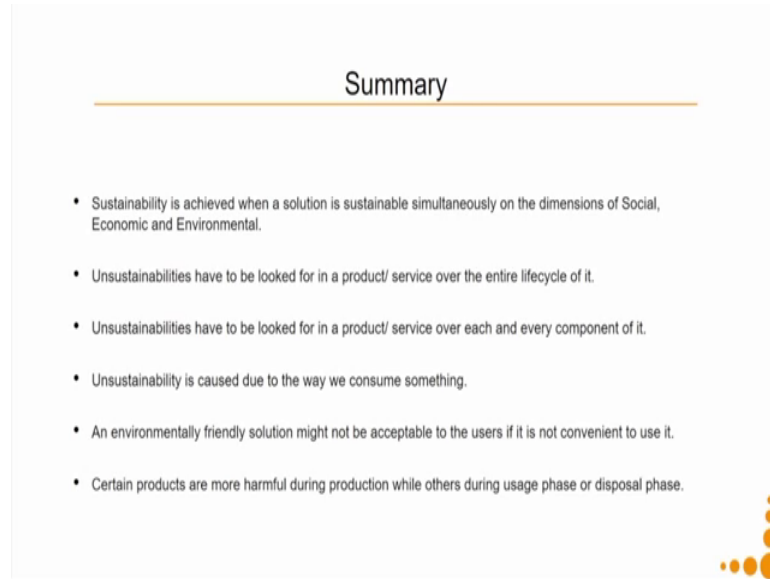
(taking in consideration the equity principle)
[Schmidt-Bleek, 1993]



Another research says that by 2050, all industrialised context. So, I am not talking about developed countries or a developing countries, I am talking about industrialised context. So, say in India we might have some contexts, where which are not very industrialised. There are other places, which are highly industrialized. So, I am talking about all the industrialised context, not in terms of developed or under developed or developing.

So, according to this research by 2050, production and consumption systems in industry industrialised context should use about 90 percent less resources than they are doing today. Just imagine, how do we achieve that, so that is the challenge in front of all the current and the future designers and engineers, so that is why we are going to do this course to try to understand how do we bring in sustainability greater sustainability than what we are doing right now.

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Summary

- Sustainability is achieved when a solution is sustainable simultaneously on the dimensions of Social, Economic and Environmental.
- Unsustainabilities have to be looked for in a product/ service over the entire lifecycle of it.
- Unsustainabilities have to be looked for in a product/ service over each and every component of it.
- Unsustainability is caused due to the way we consume something.
- An environmentally friendly solution might not be acceptable to the users if it is not convenient to use it.
- Certain products are more harmful during production while others during usage phase or disposal phase.

So, to summarise today's lecture point 1 is sustainability is achieved when a when a solution is sustainable simultaneously on the dimensions of social, economic, and environmental. The impact of each of these dimensions might not be same for a given context, they might vary. So, one dimension might be more important than another dimension

Un-sustainabilities have to be looked for in a product or service over the entire life cycle of it that is from raw material production to production of the final products and services, to distribution of the products and services, usage of the products and services, and end of life of the products and services. Also un-sustainability have to be looked for in a product or service over each and every component of it

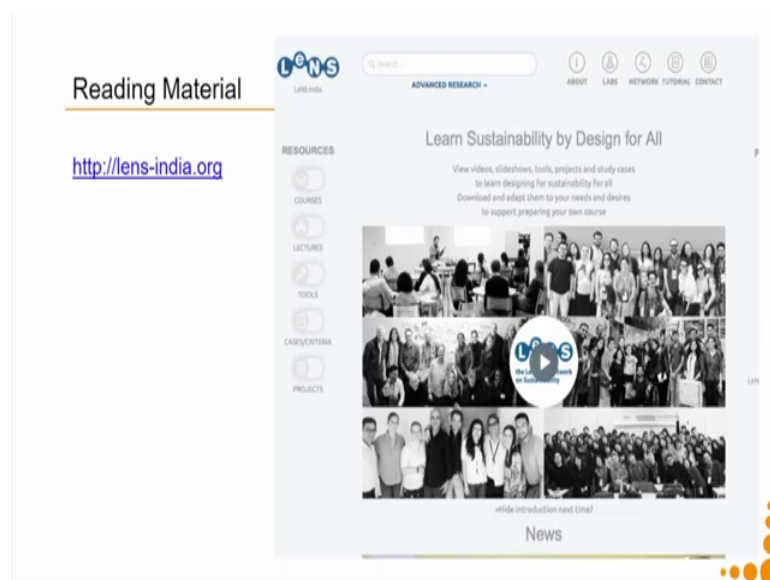
Un-sustainability is caused due to the way we consume something. So, we have to also consider; what is the consumption pattern, in case we have to work on designing for sustainability. An environmentally friendly solution might not be acceptable to the users, if it is not convenient to use it. So, many of our environment friendly or sustainable solutions actually do not work, just because of the fact that it is not very convenient to use. So, the users will not use a more friendly solution, if it is not more convenient, if it is not affordable.

Certain products are more harmful during production while others during usage phase or disposal phase. There are mathematical ways of computing in which phase a product has

what kind of impact. So, in our second module, we will go through certain strategies and tools, which help us in giving numbers to this impact.

So, when in today's lecture, I was trying to compare earthen pot versus paper plastic cup versus a plastic cup. I was talking in terms of only the different impact the different stages and the different impacts I could have, I was not talking in terms of numbers. But, there are also softwares available, which helps you to figure out the exact impact the carbon dioxide emission or the acidification caused because of a particular activity. So, we can get the actual impacts, and then compare between solutions for a given context and say which one is more sustainable.

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You can go through this particular website it is called lens India dot org. It is a group of 150 almost 150 universities from all across the globe. We are funded by the Erasmus plus program. What we are trying to do is create learning material in sustainability, so we develop lectures, we develop case studies, we also develop research material, and everything is uploaded on this website. And anybody and everybody can use all the content available on this website freely. So, we because we are talking about sustainability, and we want to bring in greater and greater sustainability, we want to leave all the educational material all the content that we developed copy left.

So, you can go to this website and this website so, this lens India is the website that the two Indian partners, which is IIT, Guwahati and Shrishti Institute of Art Design and

Technology, Bangalore we are hosting it. This website also has the links to the local websites hosted by our Brazilian partner, our Chinese partner, South African partners, and our Mexican partners and of course our Italian partners, who are the main anchors of this project.

In the next lecture, what we will discuss is about definition of sustainability and definition of sustainable development.

Thank you so much.