Life Cycle Assessment
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Lecture - 05
LCA and water, Food and Energy

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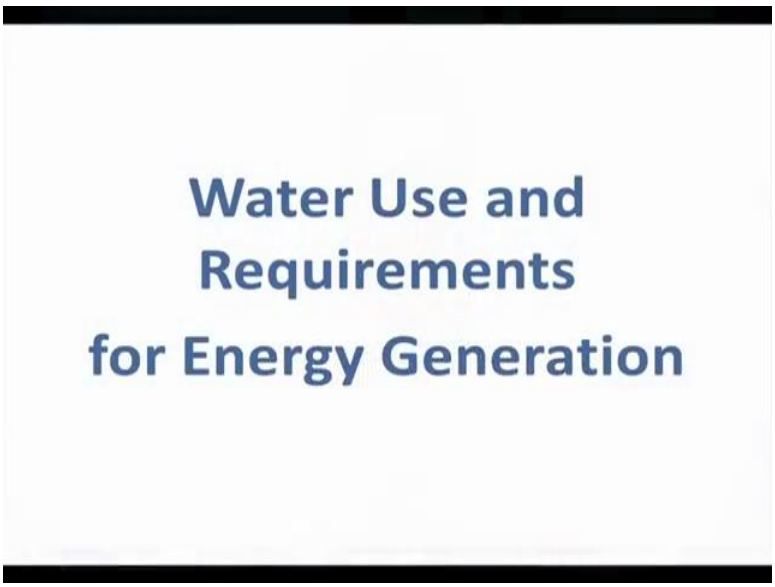

So let us get to the last module of this particular week, and this is the week one. So, as we have been discussing about the water use water demand I showed you some of the sketches some of the pictures that in the last module in terms of how the water is used in the food sector in the agricultural sector. Now we will look at water use and requirements for energy generation, and at the same time towards the end of this particular module we will also look at the water demand, what are water resources actually throughout the world and how it is changing. So, water and energy they are interlinked as you saw in the beginning of the last module.

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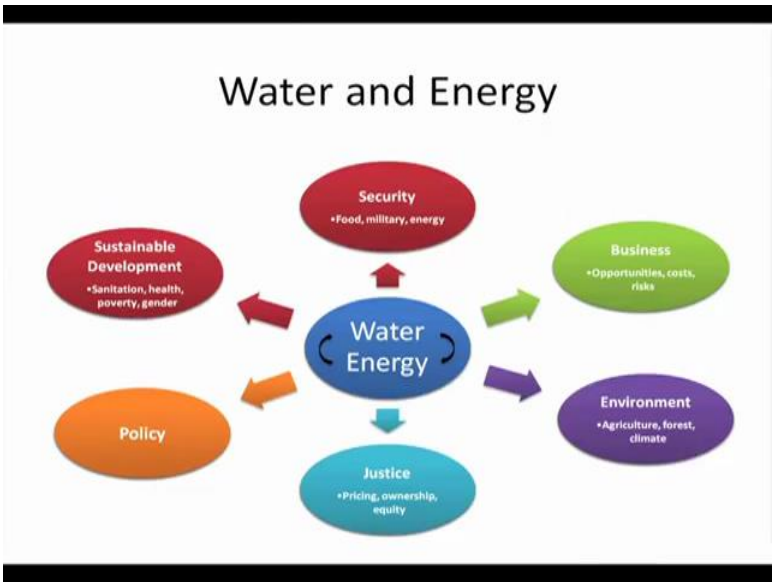

We need energy is needed for doing anything, even sitting in this room and recording this lecture for so that you can learn this course material there is lot of energy is being used over here, and same thing energy watching this video you are using energy too. So, energy is needed from every morning to till evening whatever you do we use lot of energy, and we need lot of water to generate energy which we will see as well. Water is needed for sustainable development for sanitation health, property issues, gender issues there is a policy issues of that pricing of water, who has the ownership of water environmental impact, business opportunities costs security. So, all these things are related in terms of different aspects related to the water and energy, and we will try to touch upon some of these aspects.

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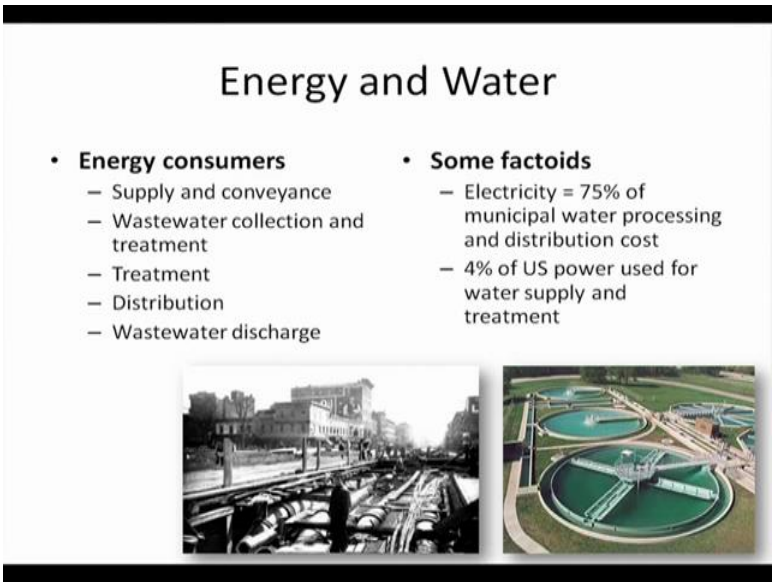

So, energy and water; energy is it is water systems is the large one of the biggest energy consumers. So, energy is consumed by the water sector, and how they get consumed in terms of the supply and conveyance. Your water supply system waste water collection system they use waste water collection and treatment system water treatment system, water distribution system, waste water discharge system, all these systems runs on what pumps and pumps runs on electricity.

So, they are consuming energy. So, in terms of some facts 75 percent of the municipal water processing and distribution cost is actually electricity cost. So, think about that 75 percent which is what almost three fourth of the cost, three fourth of the municipal water processing and distribution cost in a developed country in a developed city is actually in electricity. 4 percent of the US is power used for water supply and treatment. So, whatever the water out of the 100 percent what the energy that is used over the disused 4 percent just goes in water supply treatment waste water something will be different.

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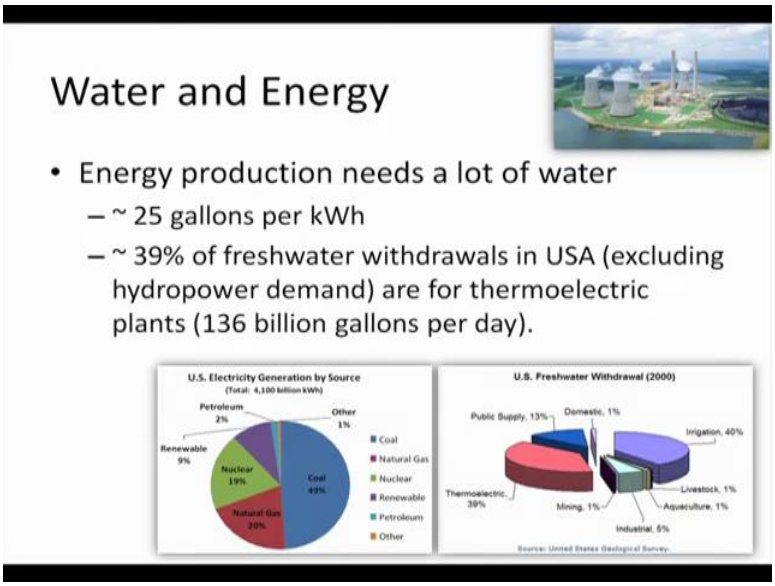

So, energy production needs a lot of water, we need 25 gallons per kilo watt hour, gallons again is a approximately 4 litres 3.8 litres. So, if you can multiplied by 4 for our it is around 100 litres or to if you take factor of that 0.2 away around 95 litres, 95 to 100 litres of water is needed per kilo watt hour. Nearly 40 percent of the fresh water withdrawals in USA excluding hydro hydropower demand are for the thermo electric plants, which is 136 billion gallons per day again gallon you multiply by 4 to get litres approximately. So, it is thermoelectric plants which is what is mostly common in India as well we are using lot of thermo electric plants here, and our energy system our efficiency system is even low. So, we will actually being using much more water as opposed to what is being used in US in terms of the per kilo watt hour.

So, if you look at the US electricity mix right now, in you see that coal is 49 percent if you go to the engine energy sector we are nearly how it is say 60 to 70 percent basement being coming out of coal. Then not much in India not much of nuclear some natural gas and some other sources like we do have some solar and some other sources renewable sources up there as well. So, US nearly for 50 percent and is actually is energy from there. In terms of the fresh water fresh water withdrawal thermo electric uses 49, 40 percent. So, this big chi big pi over there and all the nearly almost same as irrigation, so thermoelectric plant uses nearly 40 percent of the water.

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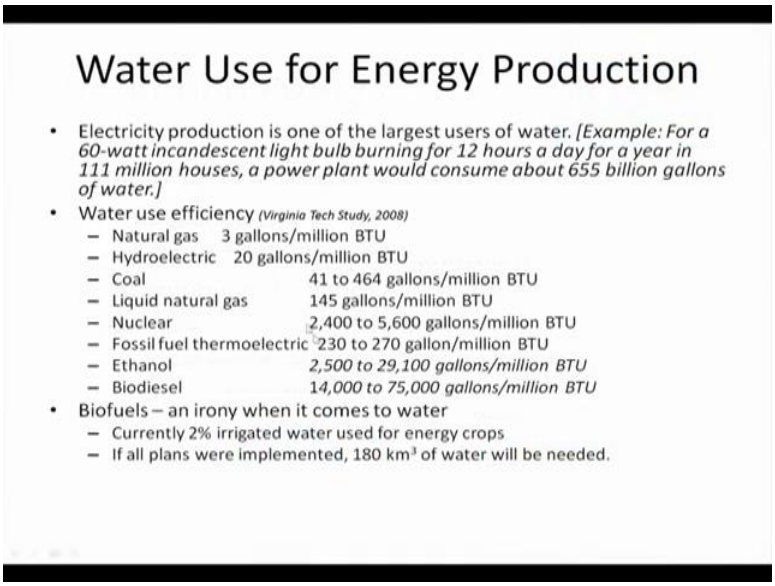

If you look at some other common stuff, we will try to we will try to discuss that in a minute. So, electricity production is one of the largest users of water for example, if you have a 60 watt incandescent light bulb, which is bulb which we use to use it still used in some places if you have a 60 watt incandescent light bulb, burning for 12 hours a day for a year in 101 million houses, a power plant would consume about 655 billion gallons of water. Multiply that by four it is around becomes 25 to 26000 billion litres of water is needed for that. So, that is a lot of water.

In terms the efficiency natural gas is uses 3 gallons per million BTU when you go to hydroelectric 20 gallons per million BTU. Coal 41 to 464 gallons per million BTU depending on the technology. LPG like liquid natural gas 145 gallons, nuclear much more 2400 to 5600 gallons per million BTU. So, in terms of the nuclear power actually nuclear power has a much like a water footprint as compared to the coal.

So, but we go for we are like a we are trying to go to nuclear power many times we even call on the nuclear power is actually a better power source then coal, again that is where the concept of this lifecycle comes in picture. You need to look at the whole you need to look at the water totality, in terms of the water footprint it is yes it has a bigger water footprint, but in terms of the other aspect it may be better that is why it is claimed that nuclear power is a actually environmentally more friendly as opposed to the coal power.

Ethanol around 2500 to 30000 that is gallons per million again do not worry too much about the gallon two litre conversion, you these are just the numbers for you to make a comparative assessment; comparative assessment for the different energy usage and you see that how the energy usage changes from one to another. Fossil fuel thermoelectric where we use like a gasoline, gas, petrol, diesel those kind of stuffs 230 to 270; ethanol much higher biodiesel lots of gallons. So, in terms of the bio fuel it is and irony when it comes to water, bio fuels are considered actually better many of people are working on biofuel in the country in India as well.

But we need to be careful in terms of the bio fuel we there are first generation second generation and third generation I will not going great detail about that, but the first generation was where we are taking the crops directly to produce energy, and that is not coming out to be good in terms of the water footprint. As you saw the earlier many of these for example, corn is used corn could be used to produce bio diesel, but the cone itself is a big way has a water footprint too. Now one you are trying to produce bio diesel, so you are you are carrying that water in terms of the water footprint with that as well.

So, now a days people are going for this second and third generation, third generation is actually from the bio waste it is the waste material which is biodegradable in nature that is being used produce bio fuel, and we should actually do an l c a exercise to find out what is the in terms of environmental footprint. So, if we all in terms of the first generation bio fuel that is why we can did become very popular, if the first generation bio fuel has to be taken up as it was planet to be taken up almost like 10 15 years back, it is a all plants were implemented it will require 180 kilometre cube of water will be needed. So, that is lot of water.

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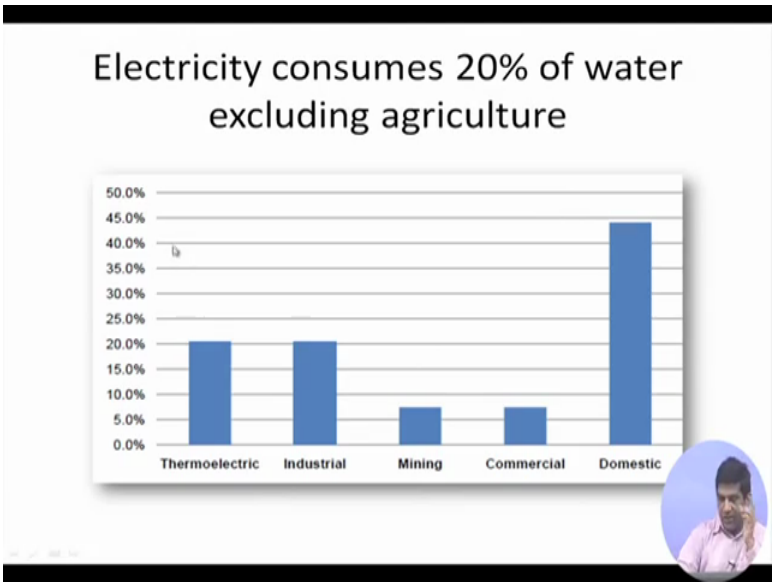

So, if you look at the other sources in terms of electricity consumes 20 percent of the water excluding agriculture. So, electricity lot of water is used other than so that is one of the highest uses of water.

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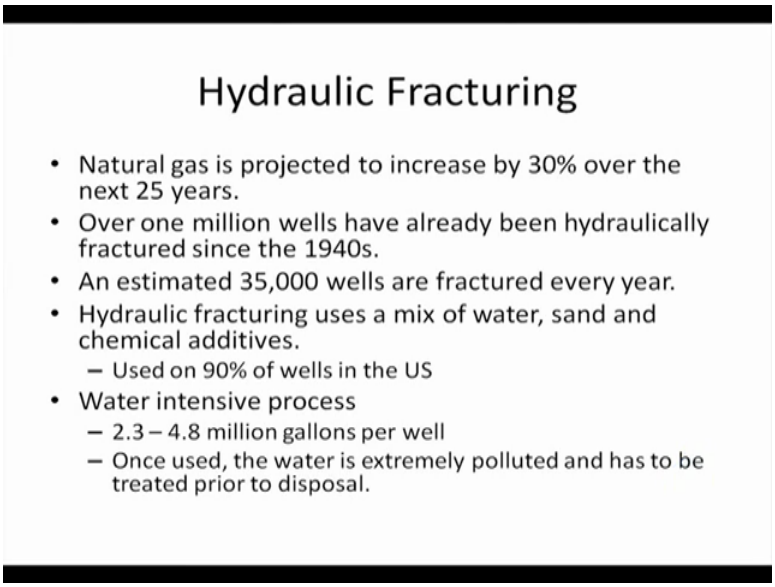

Then hydraulic fracturing these days lots of hydraulic fracking is happening where natural gas production is being increased by 30 percent over the next 25 years, and when you are go far hydro colic facture it is very similar to a mining activity.

So, you are actually pumping lot of air sorry lot of water, you are pumping lot of water in sub surface that to force this gas to come up. So, you are forcing this gas to come up by forcing by replacing this gas volume by the water volume, and when you recover some of these water the water is highly contaminated to. So, end an estimated 35000 wells are fractured every year to produce this natural gas that is called talking about North America. Now this hydraulic fracturing uses a mix of water sand and chemical additives, and uses used on 90 percent of the wells in the US that use the water. So, it is a water intensive process it is a 2.3 to 4.82 million gallons. So, that is the lots of water in 2.8 again 2.3 multiplied by 4. So, you have around 8 to 9 million litres of water per well, once use the water is extremely polluted and has to be treated.

Now, the treatment uses energy and that energy again has a water footprint. So, you think about all that that is why this concept of life cycle where you look at the whole big picture, everything in a big picture like a what is real environmental footprint the real water footprint coming up.

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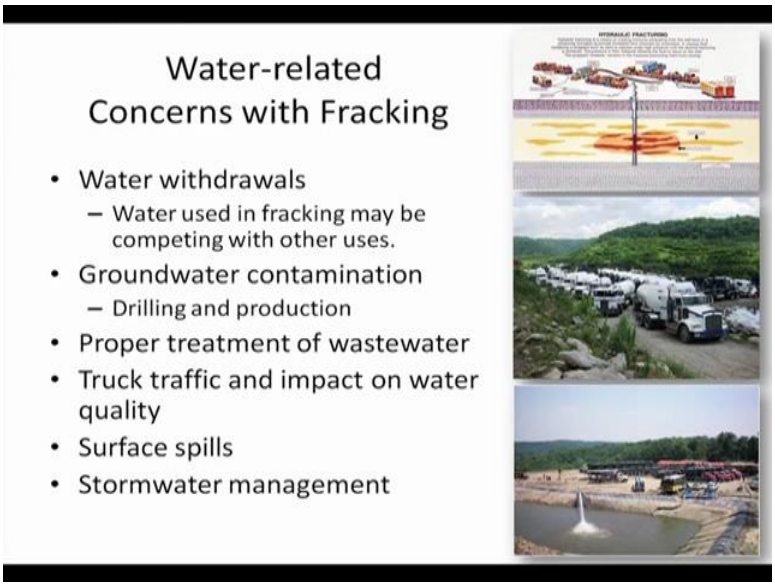

There are water related concerns are there in terms of fracking, there in terms of water withdrawals water is used in fracking may be in competing with other uses because we have water is cause in many parts of the world, ground water contamination issues because you are drilling and product producing, the pumping lot of chemicals, here you

have to have a proper treatment of the waste water that is also very much important you need to have a treatment of the waste water.

Truck traffic and impact on water quality because the traffic that is coming around to that area because will have an impact on the water quality you may have a surface spill problem, storm water management problem. So, all sorts of these things needs to be taken into the consideration with this fracking industry, but fracking industry the example for the last like last slide and this slide example to given you fracking industry because this is one of the upcoming industry which you see a lot of news about if you are if you are active in the environment field if you have follow the news on environmental field you hear at some time some of the issues associated with that.

But these kinds of things do keep on coming up in other cases as well. So, it is not only fracking today this fracking tomorrow or it to be something else. So, that is time of in terms of the energy demand of water in terms of the energy demand that is over there for energy sorry the water demand in the energy sector; now we will look at some of these global water situation or the global water stresses are coming up in different plot.

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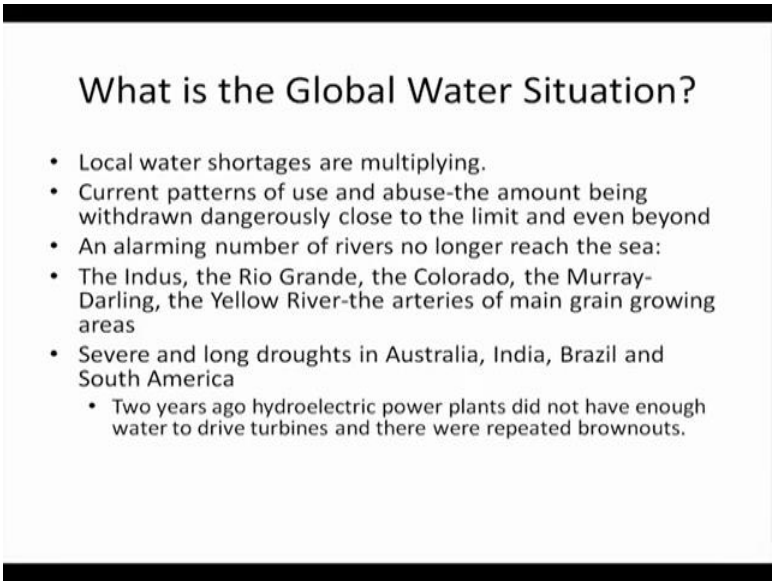

So, we have the local water shortages as you know in the in country like India one of the problem we have is some of these other than we have a rainy season which is a our monsoon season we do not have rainy season throughout the year as happens in may some of these American countries, and western European countries they have a long

rainy days. In India we have a short rainy high intensity rain in a shorter period of time that is the monsoon period mostly in I will say may June to end of August sometimes in September and then we may have some rain here and there, but most of the rain happens in the period. And after that since we are ground water recharges not happening properly we have made lot of concrete structures all around us concrete payments, and other stuff things are not things are not these are impermebial layers the ground water is not getting recharge, pounds and other things are filled up high buildings have been made on top of that.

So, we are having a big problem in terms of the ground water table is going down and with and we are pumping lost and lots of water. So, we are having a water shortages especially in the summer months, we see a water shortages is starting sometimes even some end of march and goes all the way up to June when it starts raining again. So, we are having a water shortages in many many urban cities you see that, even in the rural areas we are having the problems these days and that is why many of this toilets which are being built us part of the Swatch Bharath mission is not being used doing in the summer months, and since they are not used because they are these toilets are water intensive toilets what was you need to plush water otherwise it is tends, and if you not during the summer month what happens is it starts stinking so much that from the next season people do not use it anymore, and then those toilet becomes un useable.

So, that is the problem we have we need to have a better design in terms of those toilets as well, but if coming back to the this scenario we have the global water shortages the local water shortages are multiplying we have the current patterns of use and abuse the amount being withdrawn we are if you go into the rural areas sometimes you see the people are pumping the water for their irrigation, and they are pumping lot more than what is needed. Alarming number of rivers no longer reach the sea, the Indus river, the rio granded river, the colorado river, murray darling the yellow river, they are the main growing they are arteries of main grain growing areas, and they are seeing saviour and long droughts in Australia India brazil and south America we are having droughts two years ago the hydroelectric power plants did not have enough water to drive turbines even this year this is this not even two years like this year if you have watch the news thus the anti pricey faraka plant they could not run the turbine for few days because they

would in hidden of water. So, those things are coming up as well and they were repeated brownouts as well.

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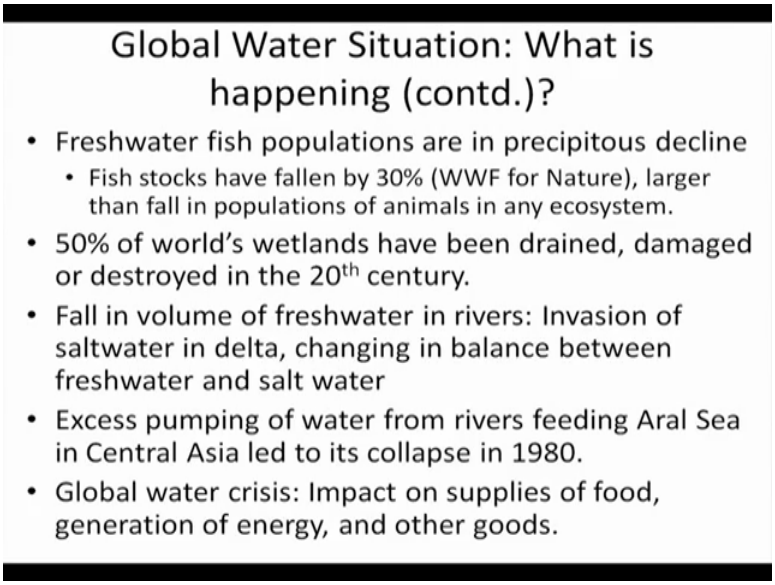

So, fresh water fish populations are in the precipitous decline, the fish population is going up fish stocks are falling down because of the lack of water, and fish stocks are have fallen by 30 percent which is the larger than fall in population of animals in any echo system. 50 percent of the world's wetlands have been drained damaged or destroyed in the twentieth century. So, think about that fall in volume of fresh water in rivers, invasion of salt water in the delta, changing in balance between fresh water and salt water, excess pumping of water from rivers feeding, Aral sea in central Asia led to it is collapse, and then we had global water crises impact on supplies of food generation of energy and. So, impact on supplies generation of energy in the other goods, those are those lead into the situation the problem as well so.

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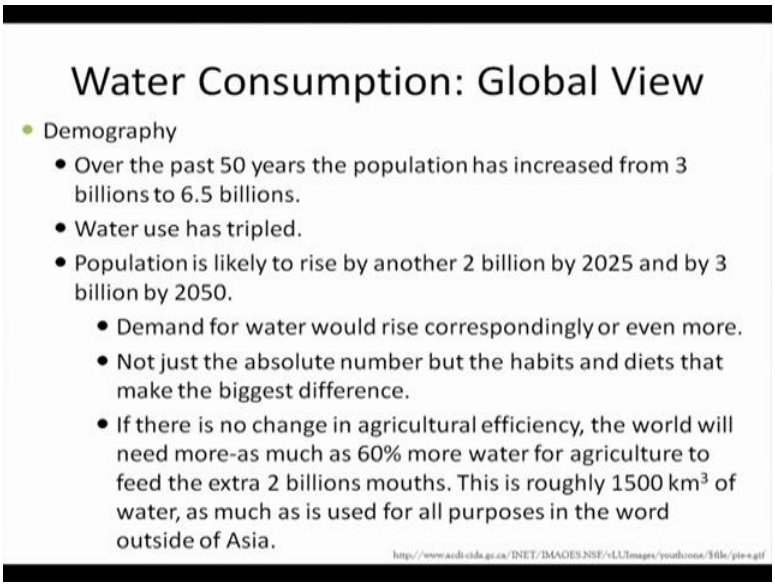

In terms of the global view in terms of demography over the past 50 years the population is increased from 3 billion to 6.5 billion. Now we are almost close to like more than 7 billion people our water use has also tripled, and our population is growing up our water use has tripled up, and we have the chance of population again rise by another two billion. So, by the by 2025 it may be around 85 billion people and then by 2050 we may have around 9 close to 10 billion people.

So, that is a lot of people and that we will have more and more water demand will be there and that is will lead to more water not just the absolute number, but the habits and diets that make the biggest difference as well as you saw in the previous slide if population move towards a non vegetarian diet lot of meaty material; that means, our water footprint goes up the kind of kind of grains with grow also has an impact on water being hope the impact of the water footprint. So, if there is no change in the if agricultural efficiency needs to improve, if the agricultural efficiency does not improve the world will need more as much as 60 percent more water for a agriculture to feed the extra two billion people, this is roughly 1500 kilo meter cube of water as much is used in entire world outside Asia right now.

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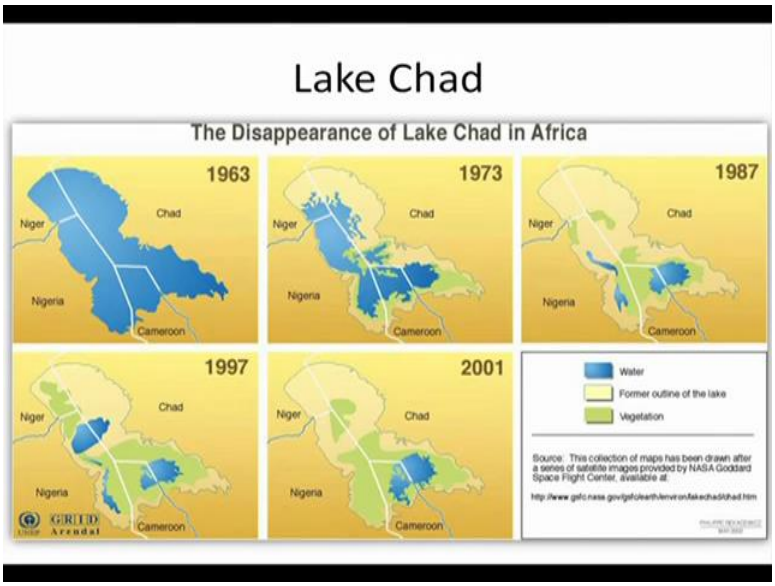

So, based on all that we have need to look at in terms the global view lots of water is needed. As I was telling you earlier if the Lake Chad has disappear the Lake Chad in Africa in this picture you see from 1963 up to 2001. So, 1963 this was the area of Lake Chad, and here the blue shows you the water, the yellow part is your former outline of the lake that is the yellow part, and the green part is the vegetation kind of converted to wetland kind of place.

So, as you go from 1963 to 1973 you see almost nearly 50 percent of the lake is gone, 1987 probably lake is gone down to may be around 10 to 15 percent, then this some improve looks like some improvement in 1997 and where you see some water coming up, but then again disappears in 2001 and now the lake is even less than 10 percent probably 6 7 of (Refer Time: 18:08) percent and this picture from the NASA website from.

So, lake is and this is similar like a last year we had big flood problem in Chennai and the flood problem was one of the article which came out is nearly more than 200 lakes of Chennai has disappeared, because those lakes used to take those water and it store it and at the same time it helps in the ground water recharge, right now we are done we have filled up all those lakes and made this higher as a building and made everything in per years. Now the water cannot flow down because it is an impervious layer of concrete as foaled as so water has to go somewhere, and if the snow waters system is choked with

plastics and other material, you have the problem of you will have the flood issue. So, these are all kind of related with that and this is probably what happens similarly in Lake Chad is no more it is what it is gone because of over usage of water.

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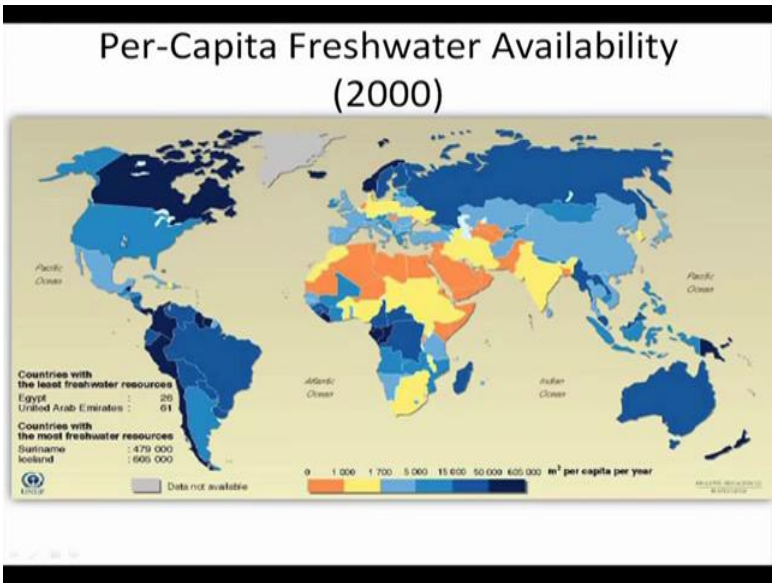

So, per capita fresh water availability; here as you go to the; I would say the orange areas which is the least water, and as you go to darker yellow is the most water. So, the most water you see in terms of the north America kind of doing Canada is doing the best interact in north America, and some of these south American countries as well; US slightly stress than Canada, but this is again this is talking about overall of the country not in the there are will be individual areas within US which are actually have having a lot of water problem. California had a big water issues over the last few years and their almond production went down in California which you like to twice in almond cost then all across the world because California it is said that this is produces almost nearly one third of the worlds almond is produced in California itself.

So, you have this if you look at the Asian countries in coming to India we are just in just above we are not in a like a very bad situation as you see some of these African countries already are including in including our friends in like our neighbours in Pakistan or Bangladesh they have in terms of fresh water availability here again in Bangladesh you will think that they have lots of rivers they have lots of lake, but the problem in

Bangladesh is there is a when you go for per capita population density Bangladesh is very high, and many of this water bodies in Bangladesh is too much contaminated now.

So, that is why you see them already in kind of a danger zone India is also kind of going towards the danger zone, and part of India is already in danger zone now as you will see as in a separate slight later on, but. So, we need to what does it mean; it means that it we need it means that we need to make sure our water whatever water we have is clean can be used up and we should be able to recycle this water, we should not waste the water we should not water wasted, but come up we need to that kind of use that. Australia New Zealand, Australia does not rain that much, but Australia population being so low we do not see much impact in terms of their per capita. So, that is why it is over there.

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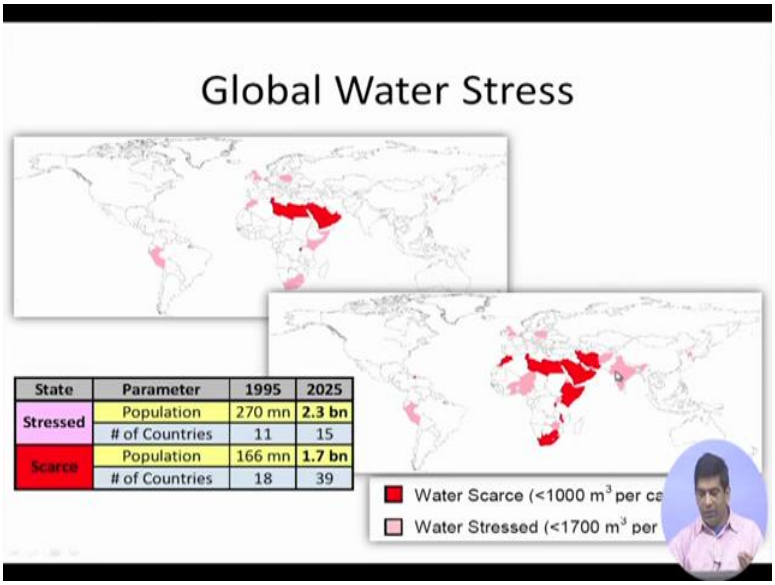

There are some areas which are already stressed like in terms of in India area, we to be have less than 1700 meter cube per capita per year. So, we are not in a water scarce we are already in water stressed, and water is scarce reasons are these all the red colour this state's this still area that you see are those are the water like a scarce area.

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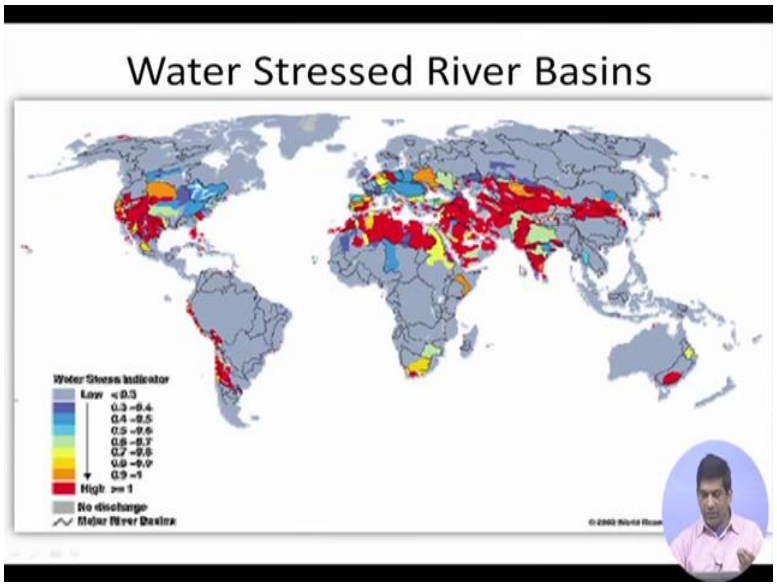

So, that is happening already, there are water stresses river basins some of them are also in India where we have the river basins which water stressed, and here you seen the some of the water areas which are the water stressed river basins represent over there.

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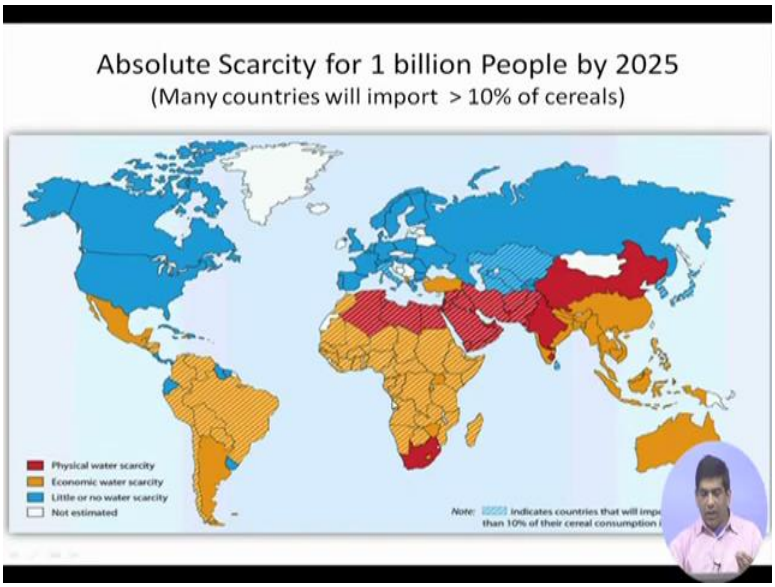

There are absolutely scarcity for one billion people by 2025. So, by 2025 we will have physical water scarcity even in most of India most of the North West and central India will have physical water scarcity, and there would be economic water scarcity in rest of the India as well. So, all of the Indian area will have some sort of water like a economic

and physical water scarcity that is a big deal actually. If you really want to make our country like a growing up we need to have water. So, that is without water we cannot do anything. So, it that is that what is to trying to highlight, if we if we cannot grow food you have to import the food and that is again that is make you wealthy that is actually training your economy.

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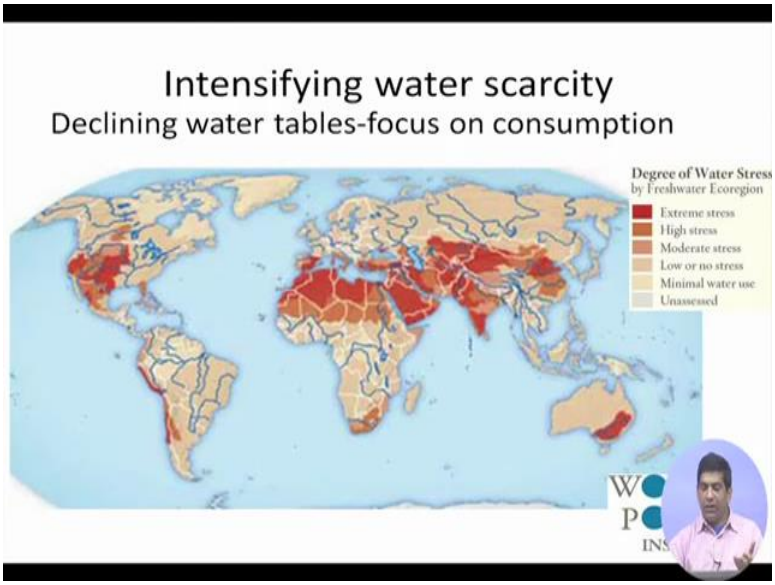

So, those things needs to be looked at we need to make sure our water resources protected, our water resources we can recharged the ground water take a take care of the ground water recharge do the rain water harvesting all sorts of things need to be done, and we to we have to come up with the processes and products which has lesser water footprint, and how will you calculate those water footprint and other that is where your lifecycle analysis tools comes in picture.

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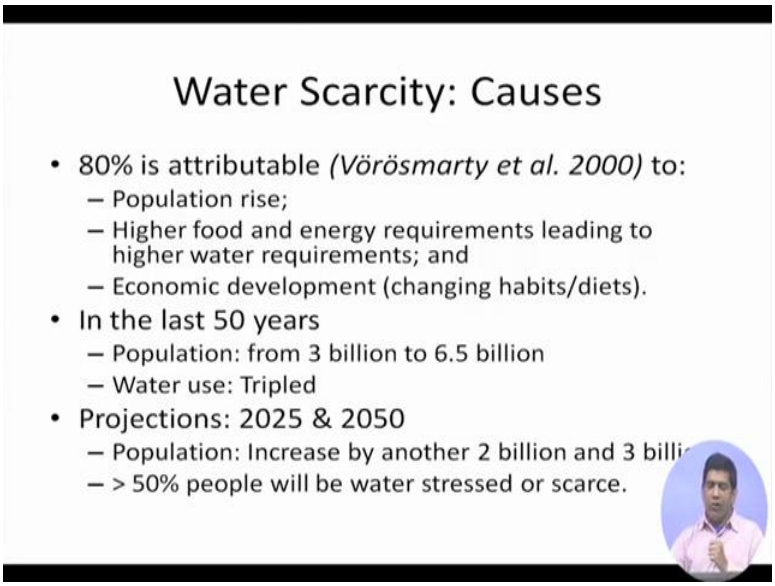

So, water scarcity what are the cause it is it 80 80 percent is attributable. Attributable means it is because of the because of the increase in population, population is going up we have the higher food and energy requirement lead into higher water requirement as you saw earlier for the most for the food as well as for the energy, we need water you already saw that in earlier slides. So, and with economic development the changing habits diets peoples are going for say air conditioners and all those kind of stuffs more things are becoming more affordable in terms of the in terms of the money that people make. So, all these leads to the water footprint on water demand.

So, it is 80 percent of the water demand, water scarcity because of it is because of population increase high food and energy requirement as well as all the economic development associated with that. In the last we are already talked about that water uses tripled and then there is a projection that by 2025 in 2050 population will be increasing another 2 billion and 3 billion more than 50 more than 50 percent of the people will be water stressed and scares think about that. So, that is why many times you hear that next world war could be on water you know. So, world population is going up, we are it is a 6.6 billion right now we are at 2016 some over here this is in this is the very big scale, so 1800, 1900, 2000, 2008.

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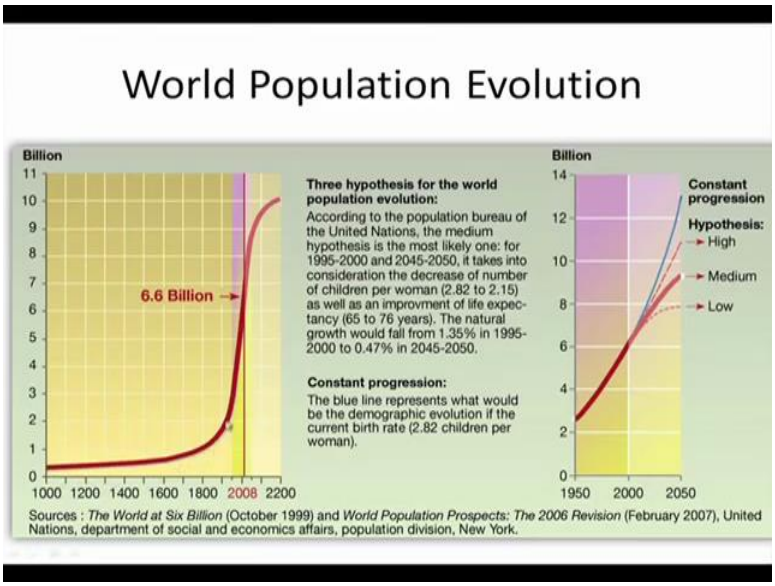

So, we have gone a little bit this is 2050 over here. So, we have gone a little bit further. So, we are around 7 billion 6 point may be around 7 billion right now, but we will it is you keep on increasing little plat up that is what it is projected and by 20 2200 which is almost 200 years from now we will see a will population of around 10 billion people on this plant. So, there are some projection here in terms of the billion there are low projection, medium projection, high projection and there was a constant progression. So, it says if things keeps on happening the way it is happening right now, you will see a probably something around range of depending on different expectations you will have a range of around if it is from 8 billon to around 13 billon the population by 2050 which is that is what is being projected for that.

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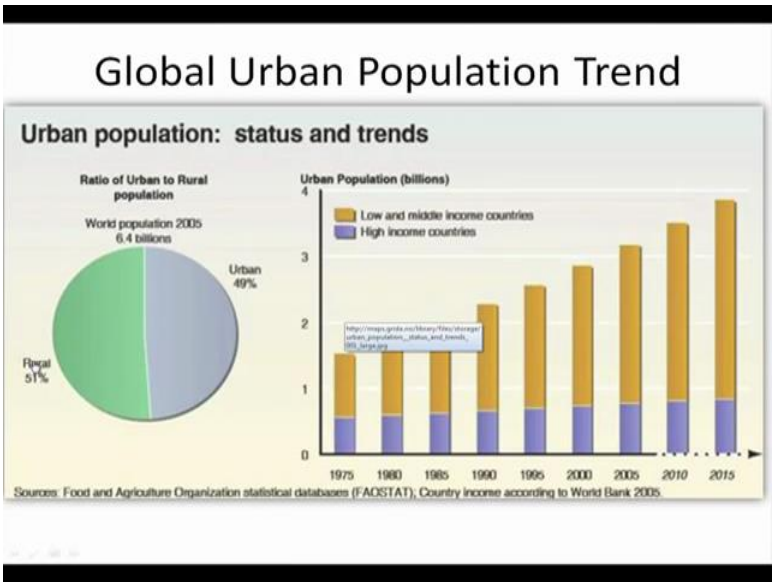

So, with the increasing population we will and what is another thing happening is the urban population is also going down, it is not only the population is increasing the population in the urban sector is going up. In world population is 2005 was 51 percent rural 49 percent urban. Just last year we had a document showing us that now most of the people like more people live in the urban areas than in rural areas in the world; in India also we are nearly earlier we use to be nearly 70 percent 70 75 percent of us use to living villages which is kind of going down to nearly 60 percent is still 40 percent our rural population is much higher than urban population, but urban population every day is growing and the rural population is going down.

So, this is more why it is important, because when we when we go to the urban population because of many of these people migrating to the urban areas they live in the slum area where they have no proper water connection system, they may not have good sanitation system, then they have the issues of this open defecation and all these comes up which impact the surface water quality. So, all these things gets lead up, and that puts a lot of stress on the urban echo system and on the urban infrastructure system in terms of the water waste water solid waste collection and all that.

So, as you see in terms of urban population which is in low and mid medium income countries are going up, in high income countries it is more or less concept we do not see much increase in terms of urban population going up in the into the high income

countries, but in the low or middle income people are moving from the rural areas to the urban areas for having a better likelihood for better schools for their kids, or the better health system. So, because of the disparity in the development in the country this is leading to the problem of like people going from rural area to the urban areas.

So, with this we will kind of wrap up this particular module and also this week's lecture. So, if you think about in this week what we have looked at, we started with the overview of the course concept of life cycle analysis was introduce a little bit will come back and have a very detail LCA exercise and during the third week which you will see that during second week will again covers some of the other basics in terms of the risk assessment toxicology and all that which. But in this particular week we made we looked at what is the water, what is what is energy, how food, how water energy food is related, how this is all related in terms of the big picture in terms of the population, human health, echo system health, environmental health also like a concept of the sustainability three pillars of sustainability are social economic and environmental aspects, and how these things are all related and then when you try to as an engineer.

When you try to design any system or you come up with any policy what are the different things you should keep in mind? These are all though many times we may not realize that these are all related I am not sure before you have gone through this last five videos whether you had the concept that if you wasting a food say if you throwing away some of the food in the trash, you are also actually increasing the water footprint.

Because you waste food waste is water waste because there is a lot of embedded water in the food; similarly if you are wasting energy if you are using too much energy and we have too much energy being used and wasted we are actually wasting water as well because there are lot of water goes into production of energy, and lot of energy is used in production water a water treatment since the in the water treatment system waste water treatment as well everything is related and will come back to then that is what makes personating it is a complex, but at the same time it is challenging and passinative. So, with this we will wrap up this week this is the last module for week one, and all again see you for your next week's module.

Thank you.