Conservation Geography
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Module - 10
Resources and Conservation
Lecture – 29
Water resources

Namaste! We carry forward our discussions on resources and conservation.

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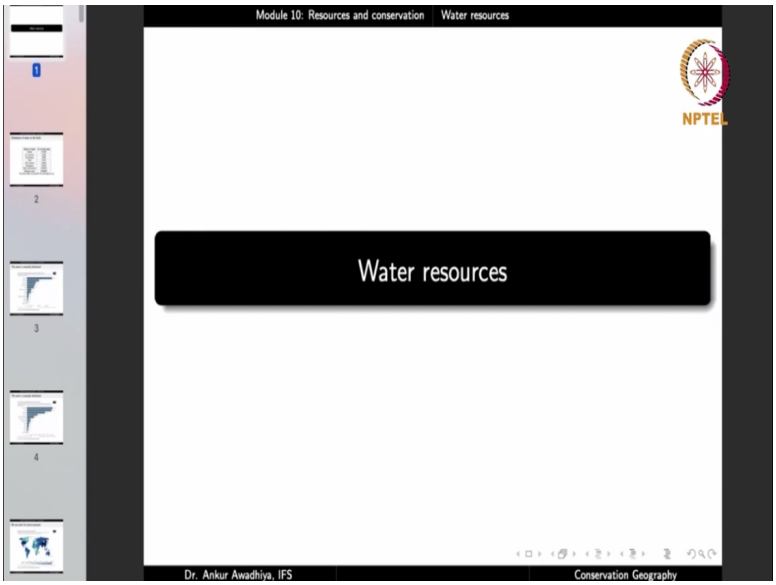

And in this lecture we shall have a look at water resources. Now, we have looked at water resources before when we were dealing with hydrosphere.

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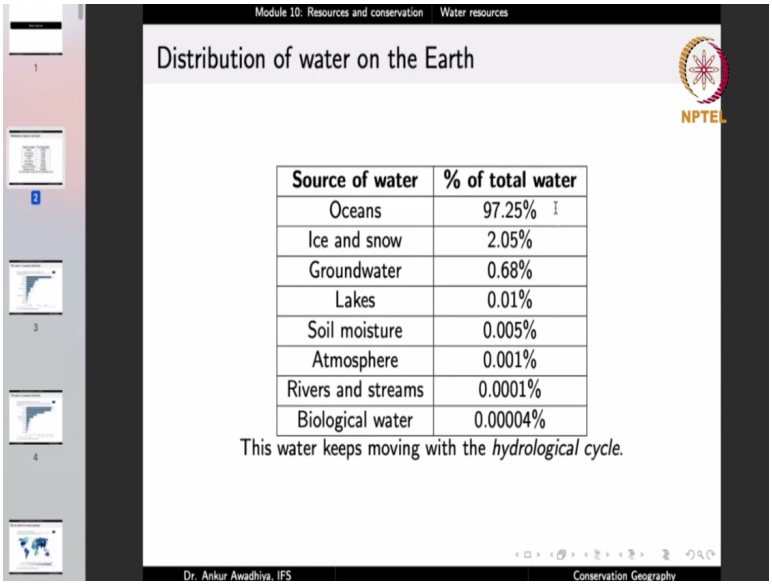

So, we had discussed that if you look at the distribution of water on the planet then around 97.25 percent of all water is there in the oceans around 2 percent is in ice and snow, 0.68 percent is groundwater and the other sources like lakes, soil moisture, atmosphere, rivers and streams and biological water make up the rest and this water keeps moving with the hydrological cycle or the water cycle.

Now, if you look at this distribution of water a few things stand out. One the largest source of water which is the oceans 97.25 percent is saline water. And so if we talk about our population requirements then this is a major chunk of water that we do not use or we cannot use for a large number of purposes. We cannot use saline water for drinking; we cannot use saline water for irrigation.

If we were to use this saline water it would have to be treated with tremendous requirements of energy and infrastructure. So, this is one major chunk of water that is not quite usable for our purposes or most of our purposes. Similarly, the ice and snow cover this is 2.05 percent of water. And this again is something that we cannot use in a large number of cases because to convert it into liquid water we will have to melt this snow and ice which again requires a lot of energy.

And so as much as 99.3 percent of water is something that is practically not available to us for our daily usage. So, the water that is available to us the largest another chunk that we have is the lakes, but that is a very small fraction of total water 0.01 percent. Soil moisture is also available for us if you want to do agriculture because plants can make use of this water,

atmospheric water comes down to us in the form of rain and rivers and streams again are unavailable source, but this is a very small source 0.0001 percent.

And we also have biological water which is water present in the plants and animals. So, this is again a very small source of water. So, the major chunks that we have are the groundwater the lakes and the rivers and the streams. Now the water that is available to us is very unequally distributed. So, we had observe that when we talk about geography we are interested in how certain phenomena are distributed around the world and the causes of those distributions.

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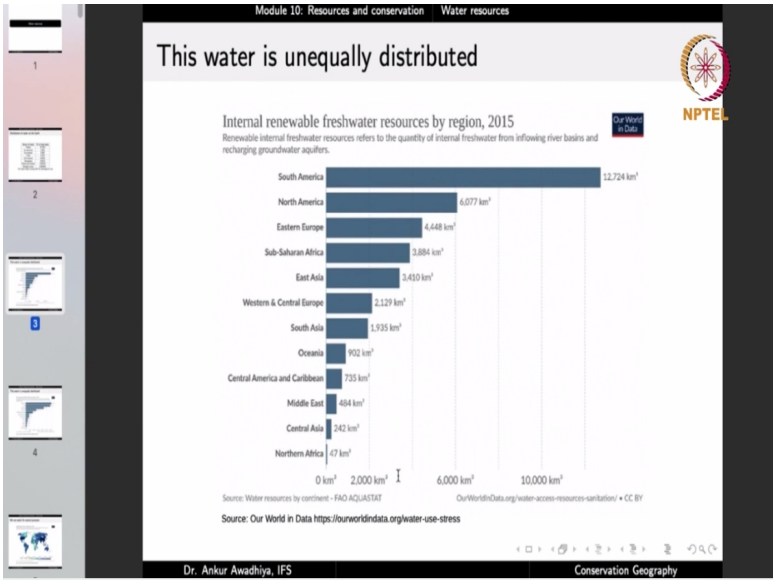

Now, in the case of the water that is available for use by humans it is also very unequally distributed. So, if we look at the internal renewable fresh water resources what does that mean? It refers to the quantity of internal fresh water from inflowing river basins and recharging groundwater aquifers that is we are considering the amount of water that is coming to us through the rivers and the water that is coming to us through groundwater recharge.

Now, in this case in South America there is a very large amount of internal renewable freshwater resource as high as 12,727 cubic kilometers. In North America it is just half of that 6,077, in Eastern Europe it is even lesser 4,448, Sub Saharan Africa even smaller 3,884, East Asia 3,410, Western and Central Europe 2,129, South Asia 1,935. Now the other portions are very small in size.

So, these are the major regions. In Middle East it is as low as 484, Central Asia again is a very added area so here again you have 242 cubic kilometers and in Northern Africa now Northern Africa is again mostly Sahara desert. So, here again you have only 47 cubic kilometers. So, different areas have different amounts of fresh water that is available to be used by different people.

Now these are the renewable sources, we also have a large number of non-renewable sources such as those aquifers that are not getting replenish now, but we are not considering those

sources we are only considering the internal renewable fresh water sources. So, the water is very unequally distributed.

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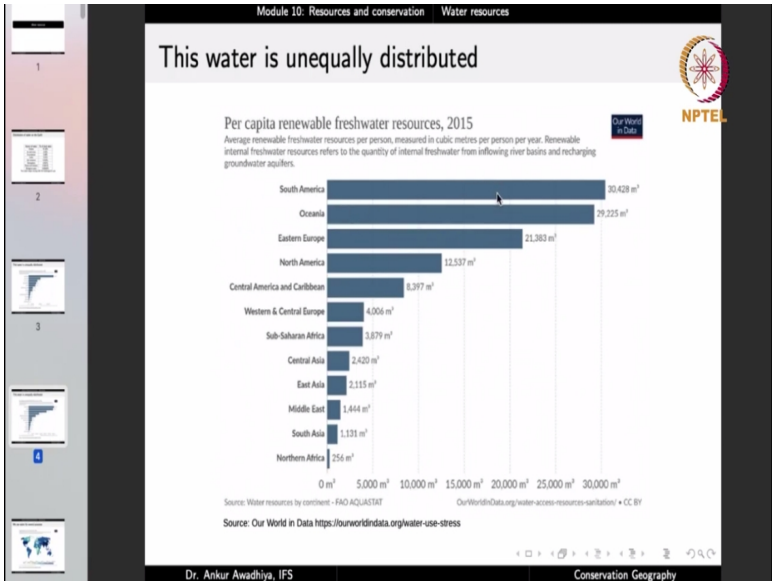

And if you look at the per capita availability of water again we find a very large difference. In South America every person has a per capita renewable freshwater resource of around 30,000 cubic meters whereas in Northern Africa it is as low as 256 cubic meters. So, this again chose that the water is very lopsidedly distributed in the world.

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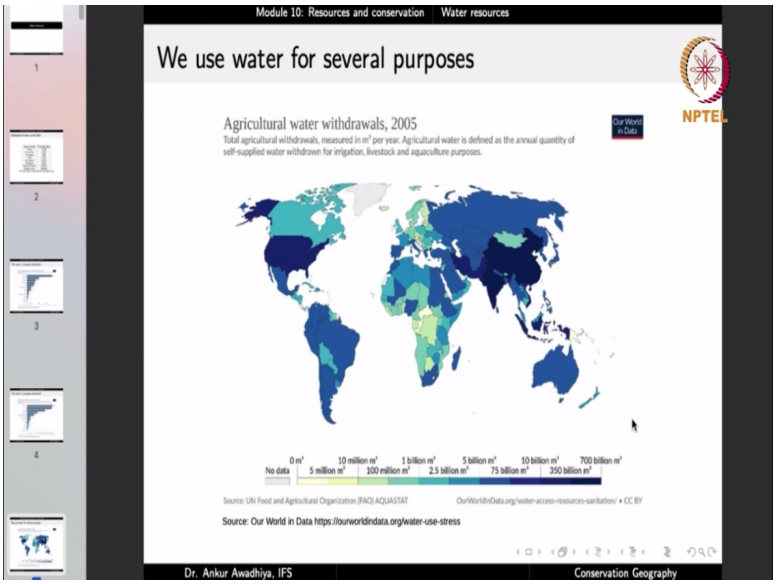

And this water is used for several different purposes. A very chunk of water is used for agriculture and we had observed in the last lecture as well that agriculture is extremely

resource intensive and it not only uses a large portion of land as much as 50 percent of our usable land is under agriculture, but it also uses a very large portion of the water that is available for human usage.

And in certain areas such as China or India or South East Asia or in the United States we are using a very large amount of water for agriculture. So, this is a chart about the agricultural water withdrawals. It is defined as the annual quantity of self supplied water withdrawn for irrigation, livestock and aquaculture purposes. So, when we say agriculture we are including growing of crops and rearing of animals including fishes.

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Now, if we look at agricultural water as a share of total water withdrawal then here again we find that in many countries such as in India, Pakistan lot of the Eastern African countries we have the agricultural water that is greater than 80 percent of the total water withdrawals that is if we consider all the water that is used for agriculture, all the water that is used for industry and all the water that is used for domestic purposes.

And here we are taking the sum of all of these three in the denominator and we are taking the agricultural water in the numerator and in these countries the agricultural water is such a large portion of the total water withdrawal that it is even greater than 80 percent whereas in the United States this is a smaller portion in terms of percentage because they are using water for other purposes even more.

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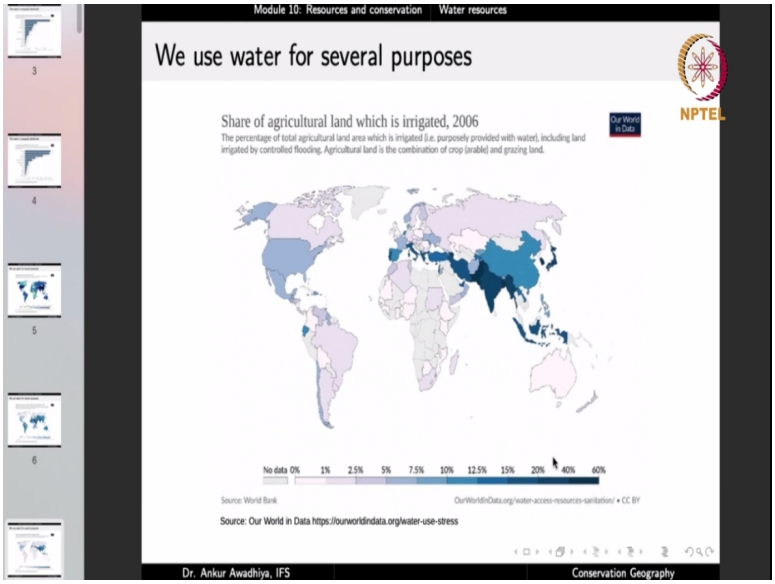

If we look at the share of agricultural land which is irrigated that is purposely provided with water then we again observe that in many countries more than 40 percent of the agricultural land is irrigated.

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Now, if we look at industrial water withdrawal so when we said that the total water withdrawal is water for agriculture, water for industry and water for domestic usage altogether. Now, we are looking at the amount of industrial water that is being withdrawn in different countries and here we observe that in the case of United States or in China or in Russia or in India and Brazil a very large portion of water.

A very large quantity of water is being used for industries. The major industries include the thermoelectric industries so where we are using thermal energy to produce electricity such as the thermal power plants and nuclear power plants.

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If we look at the industrial water as a share of total water withdrawal we will find that countries like the United States or Canada or Russia or a large number of European countries have the major chunk of water usage in the industry.

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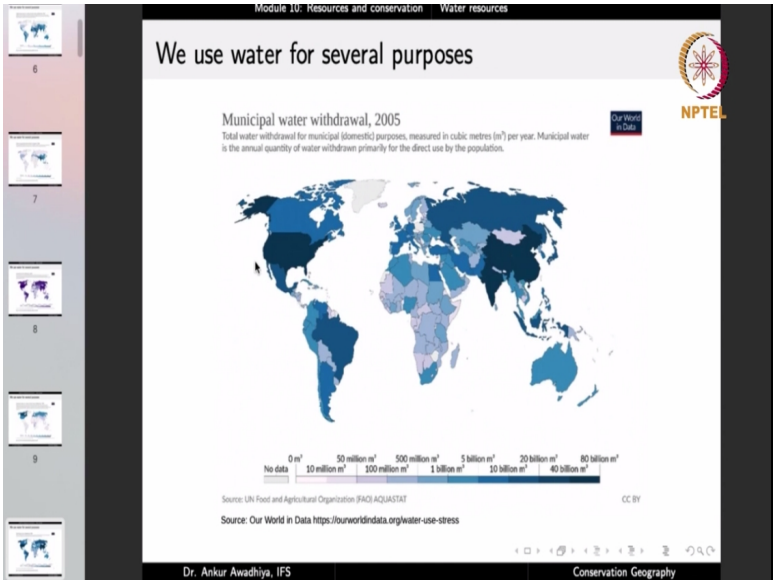

If you look at municipal water withdrawal that is for domestic purposes here again we find that in countries like India or China or the United States a very large quantum of water is being used for domestic usage.

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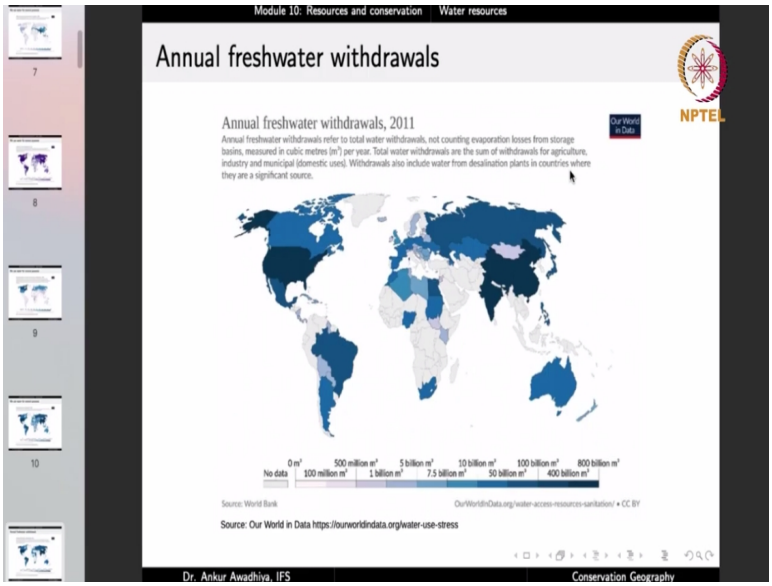

And if we look at annual freshwater withdrawals that is total water that is being withdrawn not counting the evaporation losses from storage basins then we find that in many countries like India, China and the United States and to a large extent in Russia, Australia, Brazil, Mexico a very large quantum of water is been extracted for agricultural purposes, industrial purposes and domestic purposes.

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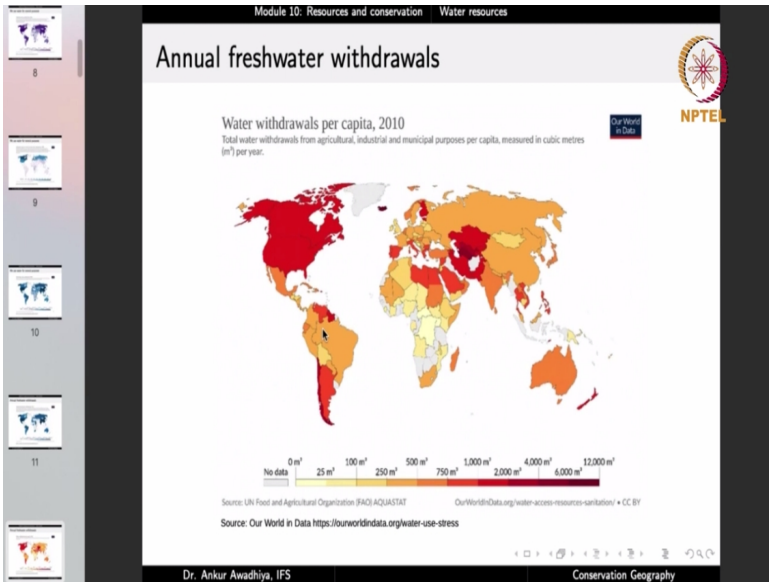

Now, if you look at the water withdrawals per capita. So, now we are looking at how much water is being withdrawn per person. Now in this case because India and China have large populations so the per capita withdrawal becomes lesser and it becomes more in the case of countries like the United States, Canada or portions in Central Asia. So, this is the chart that shows the water withdrawals per capita.

Now, in all of these charts what we are observing is that water is being extracted at different rates in different countries, in different locations. The water that is being extracted is being used for very different purposes. Some countries use a majority of their water for agriculture, some other countries use a majority of their water for industrial uses, some other countries use a majority of their water for domestic purposes.

Similarly, if we look at the water withdrawal per capita that is very different. So, there are certain countries where people are more intensive in their water usage and in certain countries people are less intensive in their water usage especially if we consider the countries in Africa then the water withdrawal is less and owing to the less population sizes the per capita water withdrawal becomes very less.

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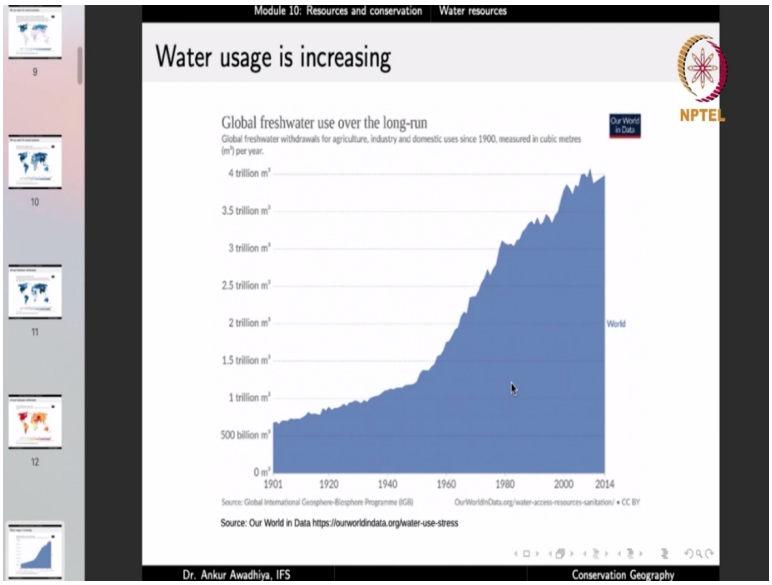

But overall if we see we will find that the water usage throughout the world is increasing. So, this chart is telling us the global freshwater use over the long run so that is from 1901 to today and what we are observing is that the water usage has been continuously increasing. Now, we are reaching nearly a plateau because we are already extracting at the maximum possible rate that is possible.

So, we are now at the stage of depleting our water resources. The water usage has to go down, but so far what we can observe is that the water usage has been increasing every year.

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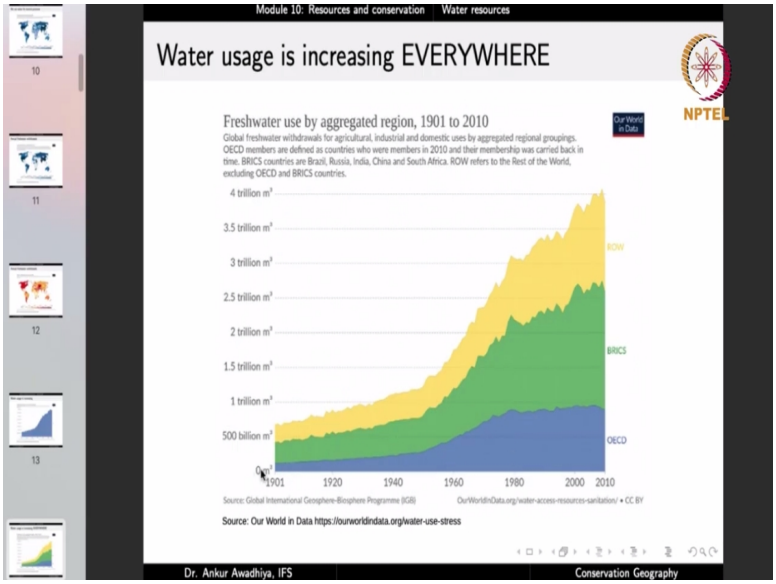

And this increases everywhere. If we looks at the BRICS countries, if we look at OECD countries, if we look at rest of the world everywhere you find the same pattern that earlier a little amount of water was being used now a much greater amount of water is being used.

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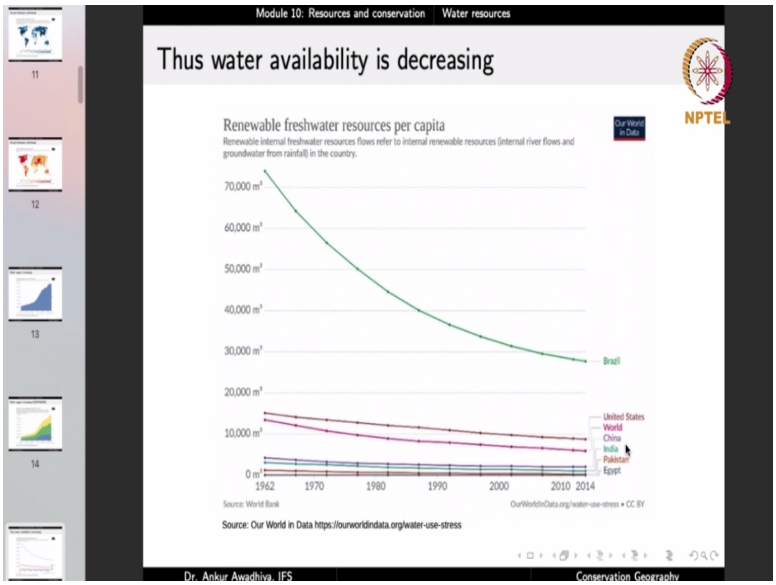

And when this happens the availability of water goes down. So, if we make a similar calculation about the renewable freshwater resources per capita then even in a country like Brazil where they have a lot of renewable freshwater that is available. The per capita

availability has been going down because a lot of water is being used and at the same time the population is also growing.

And so when we calculate anything that is per capita the denominator is the population size so when the renewable freshwater resources per capita have been going down not just in Brazil, but in all over the world. So, if we look at the chart for the US it is going down, for the world it is going down, for each and every country it is going down. So, the crux here is that the water availability is decreasing.

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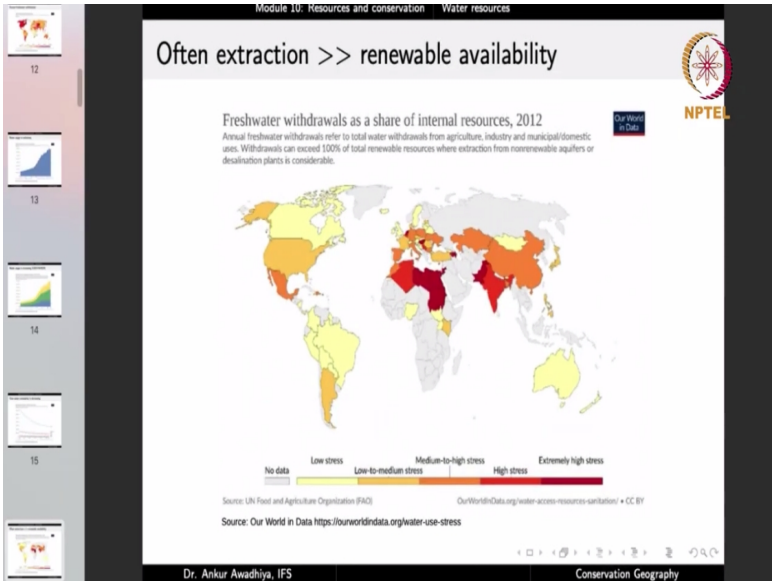

And often the amount of water that we are extracting is very much greater than the renewable availability. So, if we look at the freshwater withdrawals as a share of internal resources we find that a large number of areas mostly areas like India and Pakistan or Northern Africa are facing extremely high stress which means that in these regions the water is being extracted to the fullest possible capacity.

In certain cases we are extracting more water than is being recharged in the aquifers or more water that is being available in the streams. Now this is possible for a certain period of time because in any case if we look at the groundwater aquifers they have been recharged over millions of years, but we are overusing that water we are using it at such a fast pace that for the first time ever we will have a situation when the aquifers are completely out of water. So, this tells us that the waters are facing a huge amount of stress.

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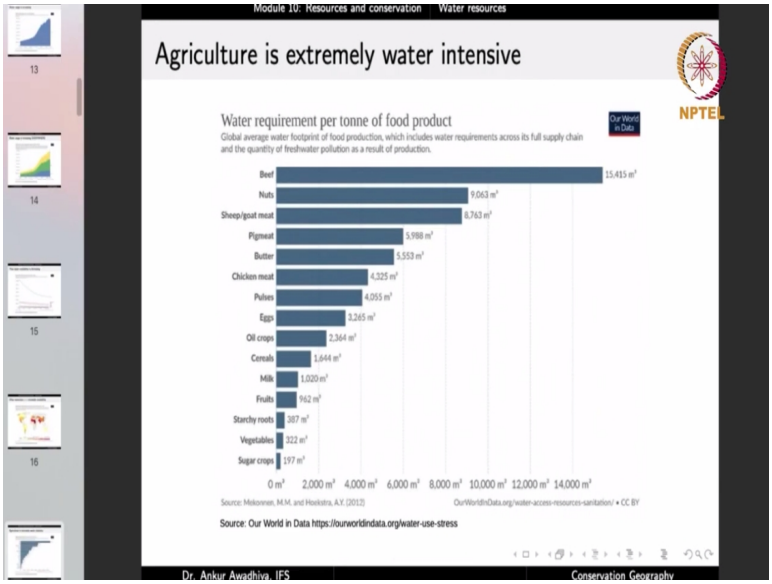

And a large portion of this water is being used for agriculture. Agriculture is extremely water intensive and especially a large number of our agricultural products or the dairy products or the animal products they are extremely water intensive. If we look at the water requirement per ton of food product we find that to make one ton of beef we require more than 15,000 cubic meters of water.

To make a ton of nuts we require 9,000 cubic meters of water now one cubic meter of water is roughly 1,000 liters. So, in this case we are talking about 9 million liters of water to make one ton of nuts 8.7 million liters of water to make one ton of sheep or goat meat. Now in a large number of cases you will observe that the products that are being derived from animals such as products like beef or sheep or goat meat or pig meat or butter or chicken meat they have a much higher utilization of water or higher requirement of water per ton of the food product as compared to items such as fruits or starchy roots or vegetables or sugar crops.

Nuts are an exception because nuts are produced by trees and the nuts are produced in a very small quantity, but the large size tree is using up a lot of water for transpiration purposes. So, these are an exception so tree crops are an exception, but overall we can observe that the animals requirement of water is much greater than those of the plants. Now one other reason why this is so is because the animal need to be feed something.

So, when we say that a goat is producing say a kilo of mutton then to make this kilo of mutton the goat would have required at least 10 Kgs or even more of certain other food items.

Now what are those food items? Typically, we feed goats and other animals with plant products. So, we will be feeding them with things like coarse grains or grasses and in these cases the water that is required for the production of these coarse grains or grasses also adds to the amount of water that is needed to make one kilo of mutton.

And so in a large number of cases we will observe that when we talk about animal sources of food they are much more water intensive as compared to plant sources of food with the notable exception of nuts that are derived from trees.

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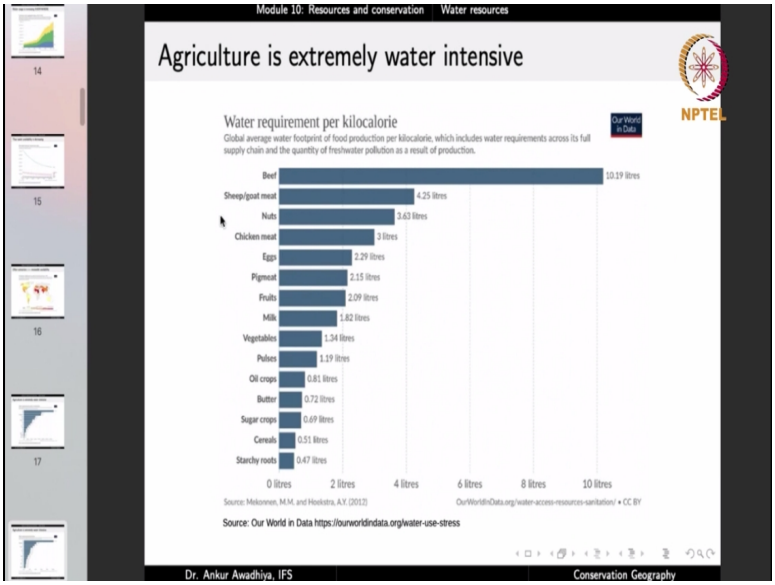

If you look at water requirement per kilo calorie of food here again we find the same thing for one kilocalorie of beef you require 10.19 liters to make one kilocalorie of sheep or goat meat you require 4.25 liters whereas to make one kilocalorie of cereals you require just half a liter of water to make one kilocalorie of starchy roots you require just 0.47 liters of water. So, typically the animal sources require more water the plant sources require less water with the exception of nuts.

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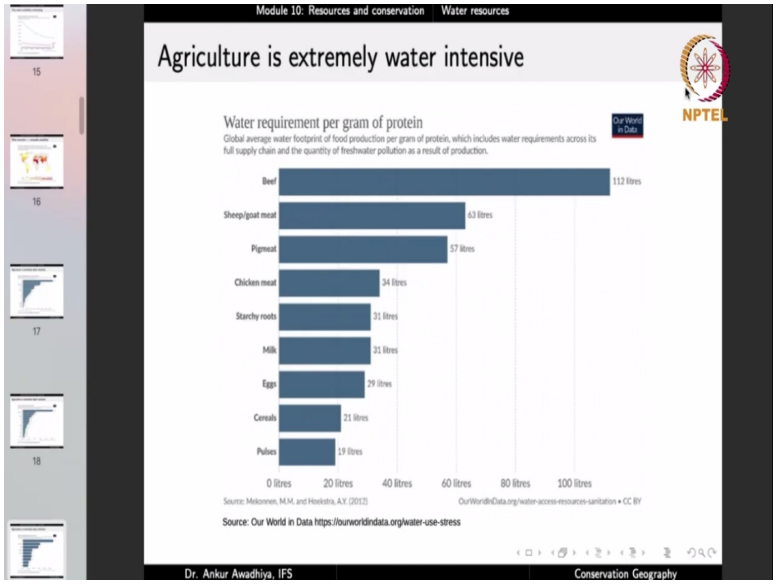

Similarly, if we made a chart of the water requirement per gram of protein here again we get the same picture to make one gram of beef you require 112 liters of water, to make one gram of sheep or goat meat you require 63 liters of water, but to make one gram of pulses protein you require only 19 liters of water. So, there is a huge quantum difference between 19 liters or 21 liters and 100 plus liters.

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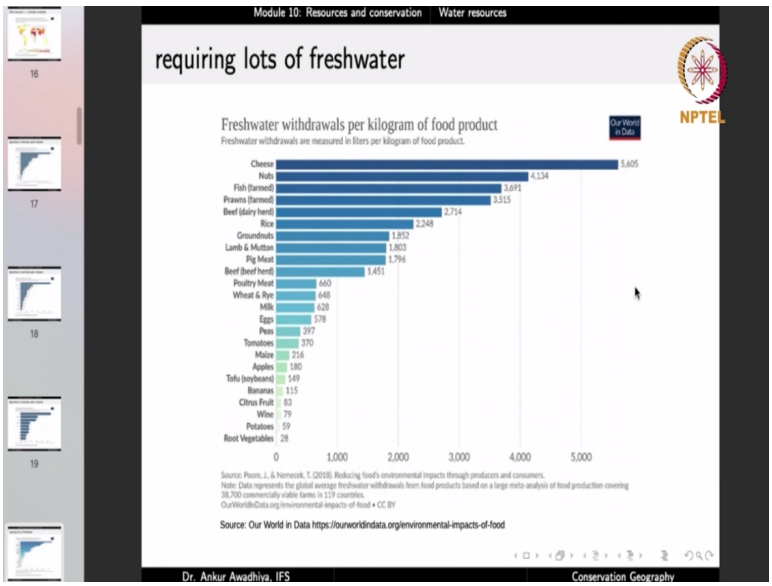

So, agriculture requires lots of freshwater. Here again if we look at the freshwater withdrawals that are happening per Kg of food product for cheese we are taking out more than 5,000 liters of water to make one Kg of cheese. We are taking out more than 4,000 liters

of water to make one Kg of nuts, but in the case of root vegetables we are taking just 28 liters of water per Kg of root vegetables, for potatoes it is 59 liters and so on.

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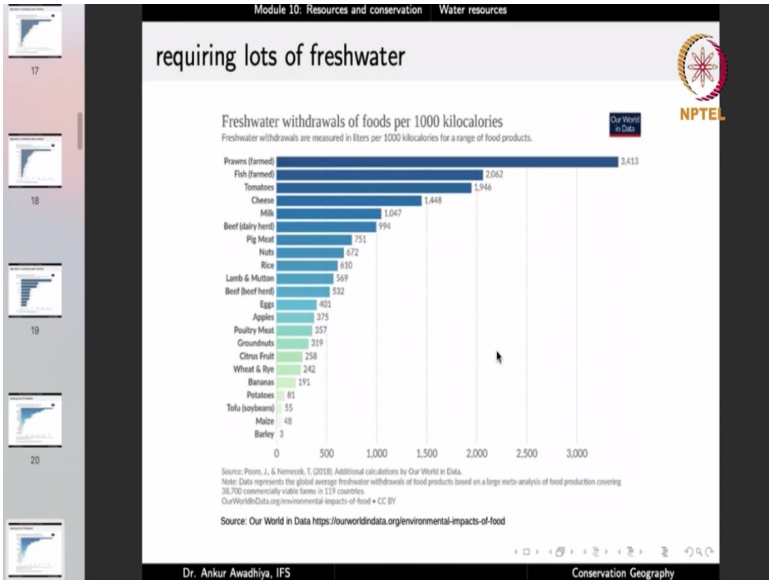

Similarly, if we look at the fresh water withdrawals of food per 1,000 kilocalories here again we get the same picture. The higher water requirements are for things like prawns, fish, tomatoes. Now tomatoes require more water because it is a juicy crop, cheese, milk, beef, pig meat, nuts and then we get the plant products like rice or apples or ground nuts and so on. So, on the lower side we find mostly the plant products.

On the upper side we find mostly the animal products with certain notable exceptions like tomatoes, nuts are not figuring here, nuts come a bit down because tomatoes also have very less amount of calories they are salad crops. So, if we did a freshwater withdrawal per 1,000 kilocalories you require lots of tomatoes to make up 1,000 kilocalories.

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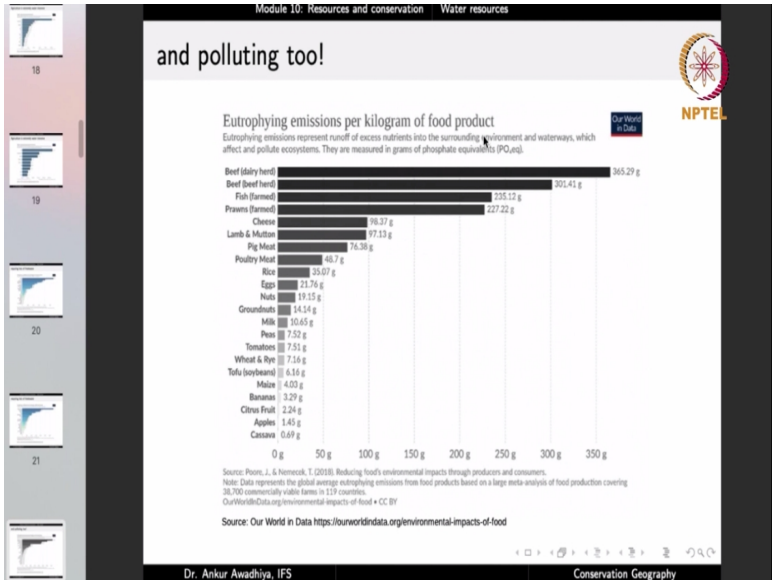

Another issue is that this agriculture is also polluting the water bodies. So, if we looked at the Eutrophying emissions per kilogram of food product which means the run off of excess nutrients into the surrounding environment and water ways which affects and pollutes the ecosystems and these are measured in grams of phosphate equivalents.

Now here again if we look at the more polluting food products these are beef from dairy herd, beef from beef herd, fish, prawns, cheese again a dairy product, lamb and mutton, pig meat, poultry meat; whereas the less polluting things include Cassava which is a root crop, apples, citrus fruits, bananas, maize, Tofu, wheat and rye, tomatoes and so on. So, here again what we are observing is that the agriculture is a hugely polluting business.

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Now one example that clearly depicts the kinds of ecosystem damages that agriculture does is the Aral Sea case study.

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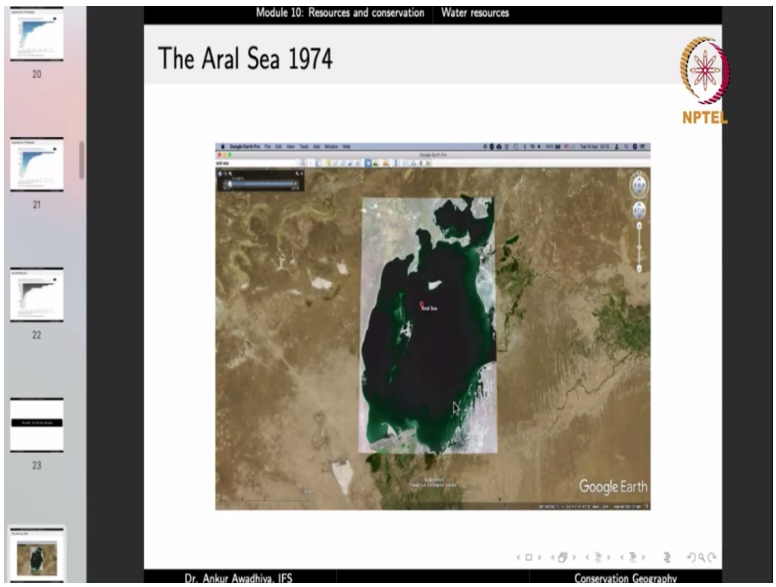

Now, if we looked at the Aral Sea 1974 it looked like this. So, this is the satellite imagery from 1974 and we can see that this is a big sized water body.

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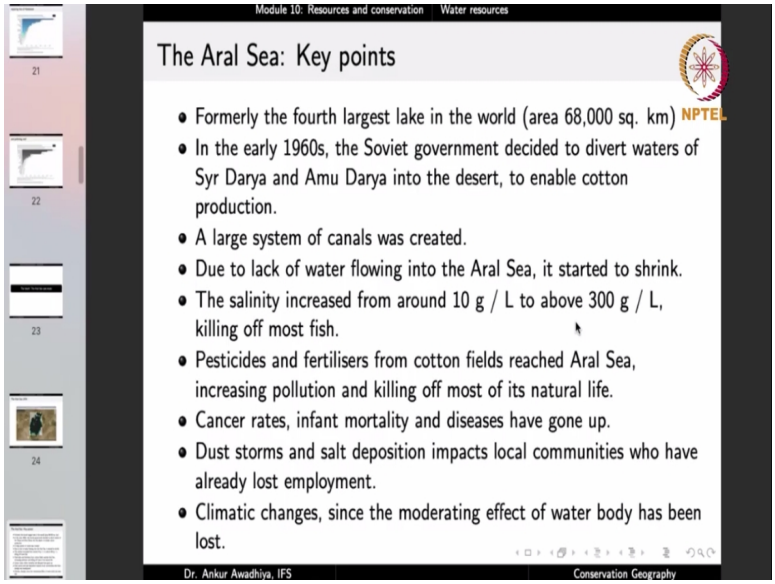

So, what are the key points? Formerly it was the fourth largest lake in the world with an area of 68,000 square kilometers. It is a very large lake so you can observe it here. Here the scale is 168 kilometers so this is roughly like 200 kilometers roughly 400 kilometers. So, it was formally the largest lake in the world with an area of 68,000 square kilometers.

In the early 1960s the Soviet government decided to divert waters of these two rivers Syr Darya and Amu Darya into the desert to enable cotton production. So, basically the government decided that we want to make this area more prosperous and because this is an agricultural region so we are going to incentivize agriculture.

To incentivize agriculture we need to bring down the cost and one way to bring down cost is by making water easily available. So, what they did was they took waters from two rivers Amu Darya and Syr Darya which were earlier putting their waters into this lake. And now this water was diverted into the desert regions and in the desert region the government incentivized the production of cotton.

Now, this is very similar to what we are observing even in our country where huge canals are being built to divert rivers for agricultural purposes. Now nothing wrong with that because agriculture requires water, but it becomes an issue when we over do it. Now in this case a large system of canals was created and will water stop flowing into the Aral Sea it started to shrink.

So, what was happening was there were two rivers that were flowing their water into this Aral Sea. Once you cut the rivers so now less water is flowing into the Aral Sea, but the amount of evaporation is still going on. Now, with huge amounts of evaporation and less fresh water to replenish it the salinity of the Aral Sea also started to increase.

So, earlier it was a freshwater ecosystem the salinity was just 10 grams per liter, but then slowly and steadily it rose to above 300 grams per liter which killed off most of the fish. Now at the same time the pesticides and fertilizers from cotton fields started to reach the Aral Sea, increasing pollution and killing of most of its natural life.

So, what was once the fourth largest freshwater lake in the world was now slowly and steadily it was dying off because of increased salinity and lots of pollution. The cancer rates, infant mortality and diseases have gone up. So, this is not without consequences for human, the humans that live nearby are now suffering from several diseases and there is a huge infant mortality in the region.

Dust storms and salt deposition impacts local communities who have already lost employment. Earlier this was largely a fishing community, but with more and more salinity and more and more pesticides and fertilizers the fish were killed off and so these people lost their employment. Climatic changes since the moderating effect of water body have been lost. So, earlier there is being a large size water body the climate in the nearby regions was very equable, but now the weather goes to the extremes.

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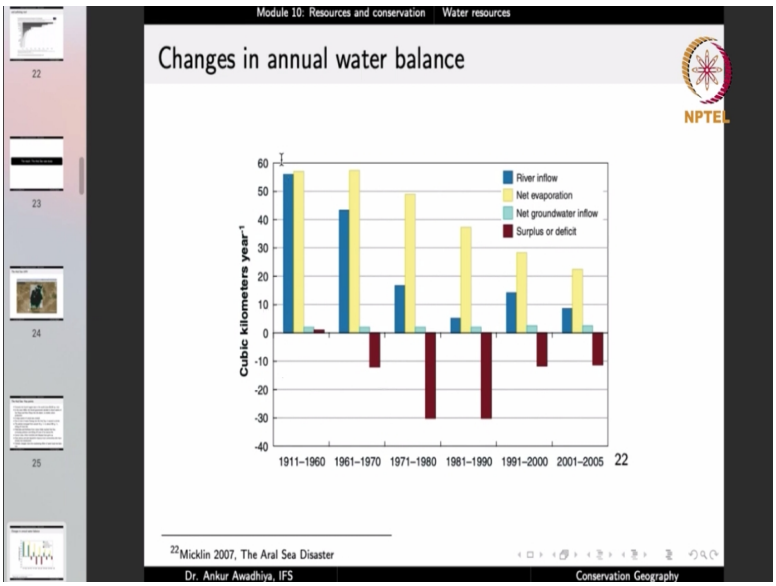

So, if you look at the changes in the annual water balance what we find is that here the blue is the river inflow. So, from 1911 to 1960 the river inflows roughly equal to the net evaporation, but the small balance is being balanced by the net groundwater inflow. So, that overall there was a net surplus of water that was getting into the Aral Sea. So, the Aral Sea was continuing because the water that was being lost because of evaporation was more than compensated by the water that was flowing in through the rivers and from the groundwater.

But then in the 1960s we started to see a net deficit of water because the river inflow went down then in the 1970s we observe that the river inflow has decreased a lot and so now the size of Aral Sea has also gone down because of which the net evaporation is also now reducing. Now this reduction in net evaporation is happening because the lake itself has shrunk.

So, the surface area has gone down and there is a huge net deficit of water in the 1980s again we find the same thing the river inflow has gone down even further and there is a huge deficit. Now by this time the governments understood that okay we have done a major blunder and so some amount of water was now permitted into the Aral Sea, but still it is facing a huge deficit of water.

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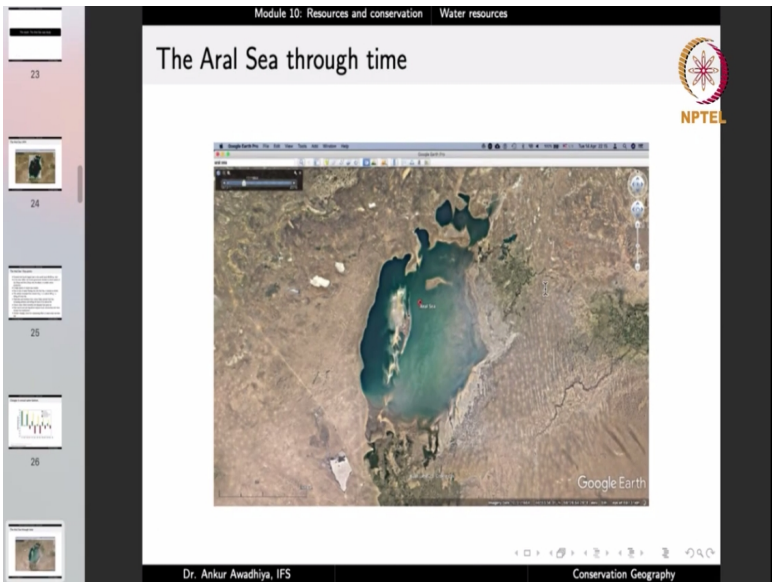

So, if we look at the Aral Sea through the time this is how it looks like. So, this is the image from 1984 and we will now just move through the different images. So, from 1984 every year you will observe that it is shrinking a bit. Now by this time the Eastern portion is roughly

gone see this becomes so small. Now this is the image from 2009; so in 2009 all of these used to be Aral Sea, but now this is small stretch.

Now, there have been attempts to improve the situation by creating of a dam and other measures, but largely the system is now completely gone. So, this was Aral Sea in 1974 this is the Aral Sea now. So, you can see the major difference how much of water we have lost. Now when such a thing happens and this happened in this particular case because of agriculture.

Now whenever we over utilize our resources especially the water resources the effects are very long lasting and the effects are very expensive in nature. So, it is not just the animals in the Aral Sea that died, but also the people who lived in the vicinity they lost their employments, they lost their culture, they lost their belongings and also they are now suffering huge burden of diseases. So, this is something to learn when we play with the natural ecosystems.

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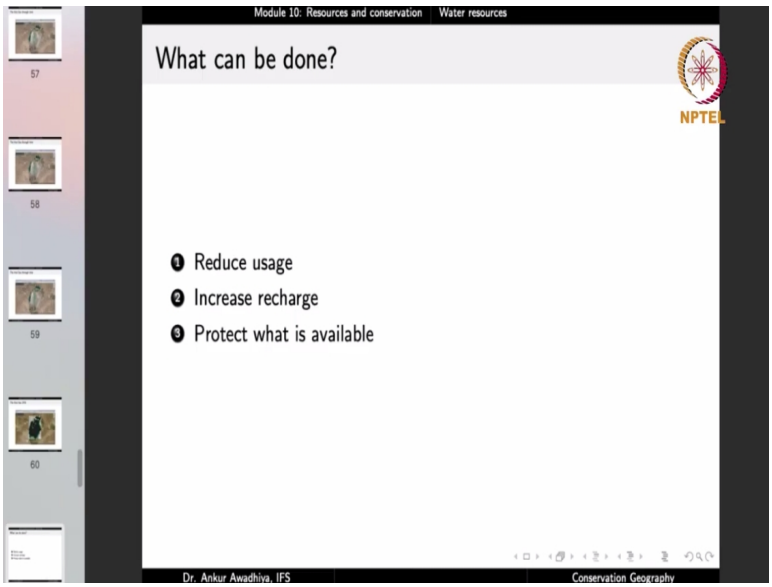

So, what can be done to prevent such a scenario? Well, there are three things to be done. Reduce the usage of water. We have observed that all over the world the water usage has been going up for two reasons. One our populations have been increasing and two we are using more and more amount of water. Water is not considered as precious today as it was in the olden days when it had to be taken out manually.

And with that our wastage has gone up. Most of the water that we use is actually the water that we are wasting so this has to be change. Second, increase the recharge of water especially the recharge of groundwater and the recharge of our inland water such as ponds and lakes that needs to be increase because we have already depleted them by a huge extent and if we go on doing like that in a very short period of time there will be no more water left.

So, we need to start working on their recharge from now onwards and three protect water available.

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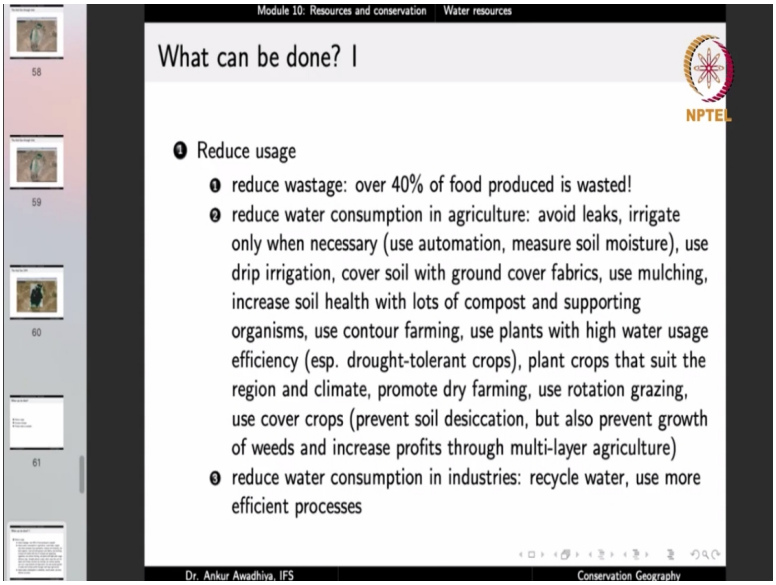

So, when we say reduce usage what can be done to reduce the usage? One, reduce wastage. For example over 40 percent of the food that is produced gets wasted and when we talk about food that is getting wasted just think about the amount of water that was required to make that food. So, when you find that say milk is getting spoiled or if there is mutton that is getting spoiled it is not just that one Kg of mutton that is getting spoiled.

It is also the 100s of liters of water that went into making that mutton. So, when we talk about reducing water usage the first thing that we can do is to reduce wastage and if we reduce wastage we can already save a huge amount of water because if this 40 percent of food produce was not wasted then so much amount of water could be saved. To reduce water consumption in agriculture, avoid leakage, think as simple as this.

If there is a pipeline ensure that there is no leak, check the pipelines, check the pump sets, irrigate only when necessary especially in those areas where electricity is highly subsidized

you can observe farmers that have turn on the tube wells and the tube wells run on and on and on even when water is not needed in the fields. Now free electricity or subsidized electricity should not mean that we should overuse the water or we have the authority to overuse the water because this water is not just for us this is also for our future generations.

If we overuse the water, if we deplete the groundwater sources then probably it will take thousands of years if not millions of years to recharge those groundwater aquifers and so this needs to stop. And in the agriculture sector it is important to irrigate only when necessary we can use things like automation, we can measure the soil moisture, these days the kids are very cheaply available so their use has to be incentivized, use drip irrigation.

Now, in the case of drip irrigation water is made available to the roots of the plants. So in place of throwing water everywhere in the field what drip irrigation does is that the water is released only near the roots of the plants. Now this has got several advantages.

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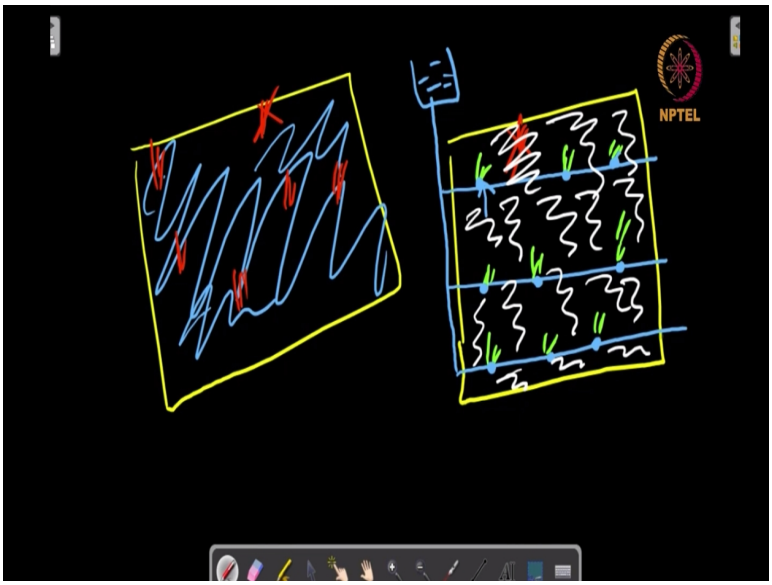

So, for example, consider two situations. So, in the first situation here you have a field and we are putting water everywhere. So, now everywhere you will find a situation that there is soil probably the soil also has a lot of fertilizers plus you have water. The issue is that it will lead to the growth of a large number of weeds everywhere because they are getting water, they are getting soil, they are getting fertilizers.

And now we will have to spend money to take these weeds out, to eliminate these weeds or we will have to spray things like weedy sides which again are toxic chemicals and what goes

around comes around. So, if we spray these toxic chemicals ultimately they are going to reach us because our crops are going to absorb some of these weedy sides or otherwise these weedy sides will get leached into our groundwater or they will get leached into our other water bodies such as streams and ultimately they are going to reach us.

So, the better way out is to not use them, but then how can we avoid these weeds. So, the way to avoid them is to go with drip irrigation. Now in the case of drip irrigation wherever we are planting the useful crops the water is released only there. So, essentially there will be pipelines that are setup and these pipelines will release the water only at those locations where the crops are.

So, the water will be released here, the water will be released here, the water will be released here and so on and the water is released drop by drop and it is released at a pace at which the plants actually use it. So, when we use drip irrigation then the water that is getting evaporated or is getting transpirated by the plants that is replenished, but we do not overdue the irrigation. So, water is not available in other areas which means that if there is a weed plant that tries to go here it does not get water.

So, the weeds automatically gets eliminated to a very large extent. At the same time the other benefits are that we reduce the amount of water usage and also that we increase the efficiency of fertilizer application because if you need to apply fertilizers you now do not have to spray them everywhere you can just add them to the water source. And these fertilizers will be provided right to the roots of the plants.

So, drip irrigation needs to be incentivized, cover soil with ground cover fabrics or muse mulching. Now what is that? When we have these plants another thing that can be done is to cover the other areas with something and this something can be things like ground cover fabric or just mulch. You can even use straw or excess leaves that have fallen and they can be used to cover the ground. Now covering of ground using mulch provide several advantages.

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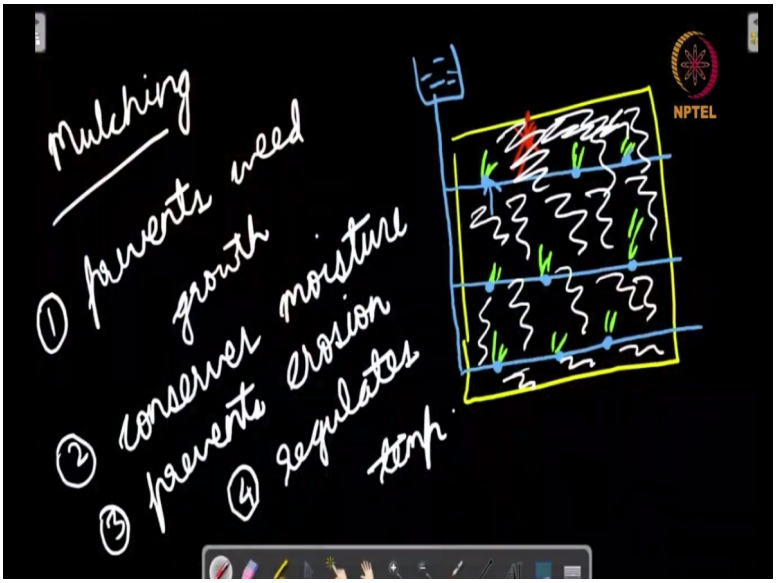

So, when we are using mulching the first thing is that it prevents weed growth. Why because the weed require sunlight and once you have covered the ground with a fabric or with the mulch then you cut down the supply of sunlight and so the weeds cannot grow here. Two it conserves moisture why because it prevents sunlight from desiccating the soil it is acting as a cover on top of the soil.

Three it prevents erosion again by covering the soil it is providing a protective layer. Four, it regulates the temperature in the soil. So, in the night time the soil will not become extremely cool the crops will not be damaged through things like frost because it is an insulating layer. So, when we use these techniques to converse moisture they also have a large number of other positive side effects.

So, why not use them. Increase soil health with lots of compost and supporting organisms. Now compost and supporting organism such as earthworms increase the fertility of the soil, but they do that without causing pollution because we are not using industrial chemicals, we are not using artificial chemicals like fertilizers to improve the soil this being done naturally at a pace that provides the plants with the requisite nutrients.

In the case of fertilizers the problem is that if we apply too much of fertilizers it kills of most of the organism it gets washed off into the water streams, but in the case of composting or using earthworms such drawbacks do not occur. So, the water is preserved it is not contaminated, use contour farming. Now what is contour farming?

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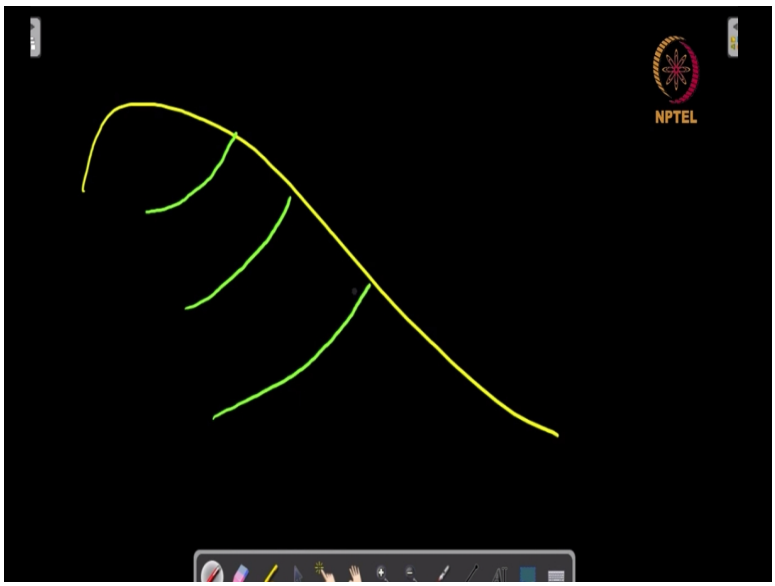

In the case of hilly regions we can plant our crops in contours that is at all the locations that are at the same height we can make the plants grow there.

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Another way out is by using stepped agriculture so that is the fields will look like this. So, in this case here we will be having the crops and the best thing about this is that it reduces the speed of water. Earlier any water that felt down would have directly move down, but now the water can only move to this distance and then it is stopped by these plants, the speed reduces then again the water has to start from 0.

It flows to this distance again the speed stops and then again the speed it moves here again the speed stops and so on. So, at all locations the water is moving at a very slow speed. Water moving at slow speeds means that there is less amount of erosion, less amount of sediments in the water plus the water is also recharged into the hill because after all what is groundwater recharge?

Groundwater recharge is the process in which we make a running water walk, walking water stand and standing water to seep that is the only thing. So, if you reduce the speed of water it has more chances of moving into the ground of infiltrating inside, percolating down. So, this is another way. Use plants with high water usage efficiencies especially drought tolerant crops.

So, if we use drought tolerant varieties of crops then we do not have to pour so much amount of water into the fields. So, we can cut down on water usage just by using a better variety of the crop or plant crops that suit the region and the climate. If it is a desert area do not grow paddy grow something that requires less water, promote dry farming which is farming with very little amount of water or use rotation grazing.

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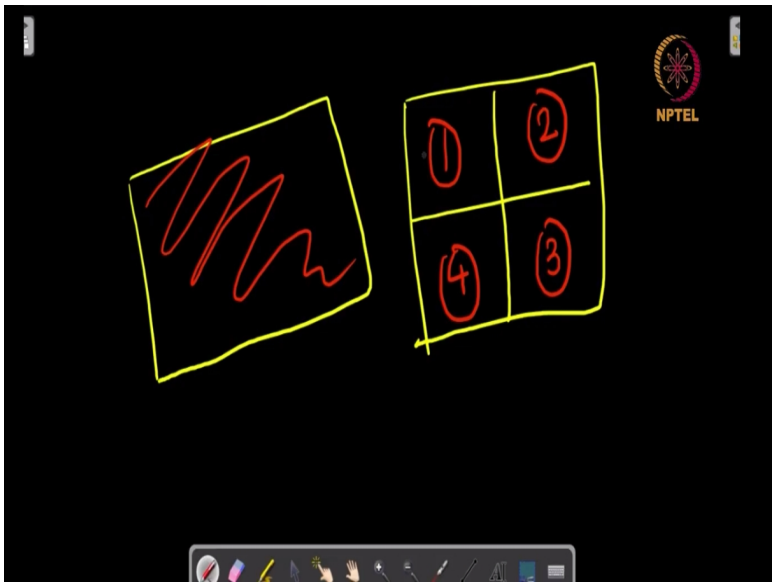

Rotation grazing means that if we have a field or say a pasture land and all of these pasture land is grazed at the same time in that case the soil will be left exposed, there will be soil erosion and there will be desiccation of soil, loss of moisture whereas a much better way is to do rotation grazing in which case we divide the pasture land into different segments and firstly the cattle will graze in one section.

Then they will graze in the second section then in the third section then in the fourth section and by the time they come back to the first section the grass has had time to replenish itself. So, at all points of time we ensure that the soil is never left bare. So, this can also help or use cover crops. Now cover crops are similar to the use of mulch, they prevent soil desiccation and they also prevent the growth of weeds and increase profits through multilayer agriculture.

So, for example if you are growing a crop like haldi, that is turmeric, which can grow in the shade what stops you from growing a tree in the same farm land. So, if you grow say a mango tree together with the turmeric then you can have income from mango as well as turmeric because both of these plants do not compete with each other and at the same time the mango will provide shade to the turmeric so that the growth of turmeric also increases.

So, this is known as multilayered agriculture then we can reduce water consumption in the industries by recycling water using more efficient processes.

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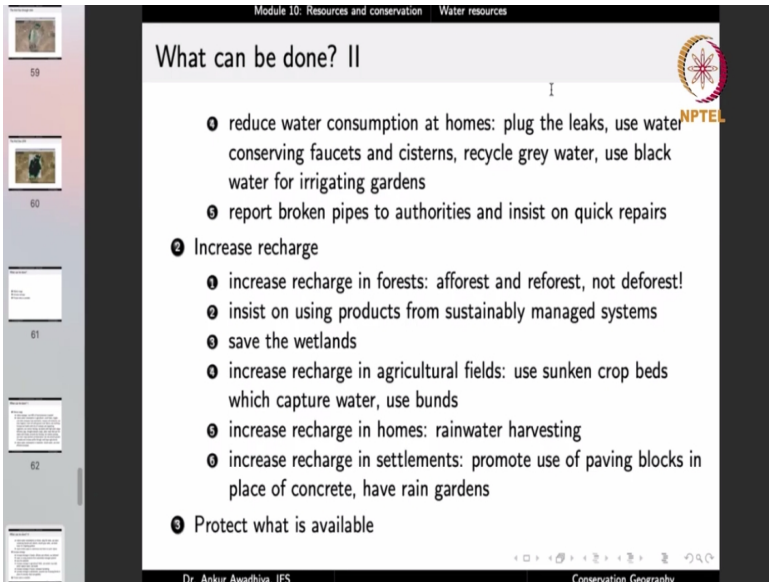

Or we can work at reducing water consumption at homes by plugging the leaks using water conserving, faucets and cistern, recycling grey water meaning that the water that is not very polluted can be used for certain purposes such as flushing of toilets and we can even use black water that is the water with sewage for irrigating gardens, report broken pipes to authorities insist on quick repairs so that water is conserved or we can work at increasing recharge.

A lot of recharge happens in forest so we can go with a forestation, reforestation and try to prevent deforestation. We can insist on using products from sustainably managed systems especially sustainably managed forest. To ensure that when we are using a wood product then we are not cutting down a forest to get that wood it has to be sustainably managed in a way that there is always a tree cover on the piece of land so that it continues to recharge the groundwater.

We can insist on saving the wetlands. Wetlands are one major source of recharging ground waters, increase recharge in agricultural fields by using sunken crop beds which capture water and by using bunds. So, what is a sunken crop bed?

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In the case of a sunken crop bed we make beds that are sunken downwards and then we grow our crops in these locations. So, when that happens whenever there is rainfall then water can collect in these sunken beds and this water can be moved into the groundwater or we can try to increase recharge in homes by doing rainwater harvesting. Increase recharge in settlements by promoting the use of paving blocks in place of concrete and by having green gardens.

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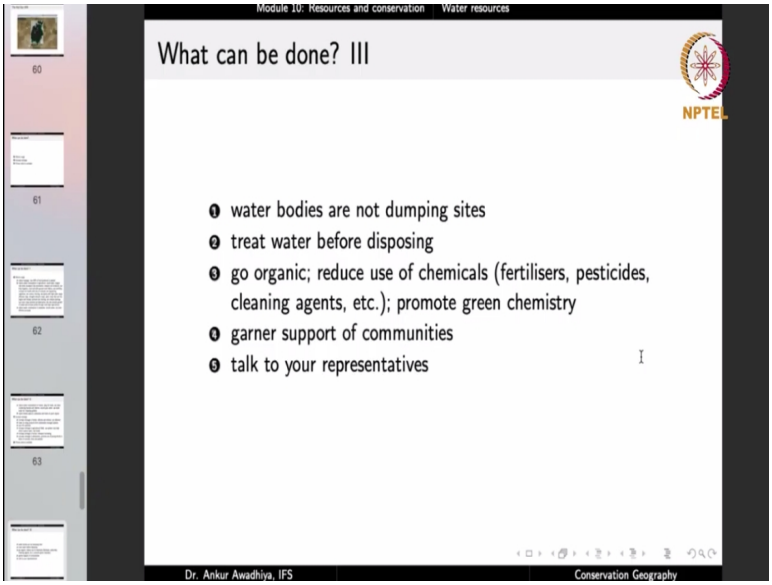

And also we need to protect what is available because water bodies are not dumping sites. If you find something who is polluting a water source you should stop that person tell that person that the water is important and it needs to be conserved. If you live in an area where the sewage is being dumped into say a pond or a lake or into a river you should write to your authorities insisting that these waters are not dead.

We need to treat water before disposing both the municipal sewage water and the industrial waters. We need to go organic, reduce the use of chemicals such as fertilizers, pesticides, cleaning agents and so on because they will ultimately make way into the water systems, promote green chemistry, garner support of communities and talk to your representatives, your representatives especially the members of parliament and the members of legislative assemblies can be impressed upon that water needs to be conserved.

And laws need to be made to ensure that water bodies are not polluted that our wetlands are saved and that we have sufficient amount of groundwater recharge.

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Now, let us look at a case study of how simple it is to conserve water. So, when I was posted in Bhopal I was allotted a government residence and it was a newly constructed house. So, this is the backyard of this house and as you can see there is hardly any vegetation in the backyard. There was a slope from this side to that side. So, this is the direction in which water will flow and in this region you find no vegetation.

Primarily because this soil was having a very lack of humus and also the water availability in this area was typically low and especially in the summer month. Now water and vegetation have a very intricate roles in intricate relationships with each other. So, if you have water there will be vegetation and when there is vegetations it will conserve water so it will increase the amount of water availability in the area primarily through promoting groundwater recharge and by protecting the soil against desiccation.

So, once you have an area that has sufficient amount of vegetation you will have more and more water that is available and more and more vegetation can come up. You just need to start the process. So, this is something that I got to start with.

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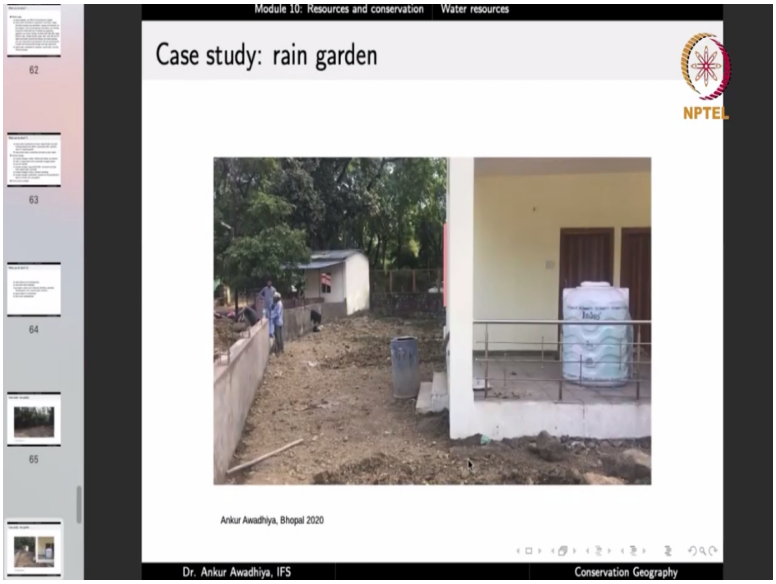

This is the other side of the house and here again you can observe that there is no vegetation whatsoever. Now the good thing was that when I got this house these areas were yet to be finished and in most of the government accommodations you would find that people go with concreting of the surfaces.

So, that is in all of these locations there will be a concrete layer poured and primarily in these areas probably people will go with say construction of a tennis court or a badminton court or something, but I had other plans. So, what I did was I made space for plants and I insisted that all these areas should be paved with paving blocks.

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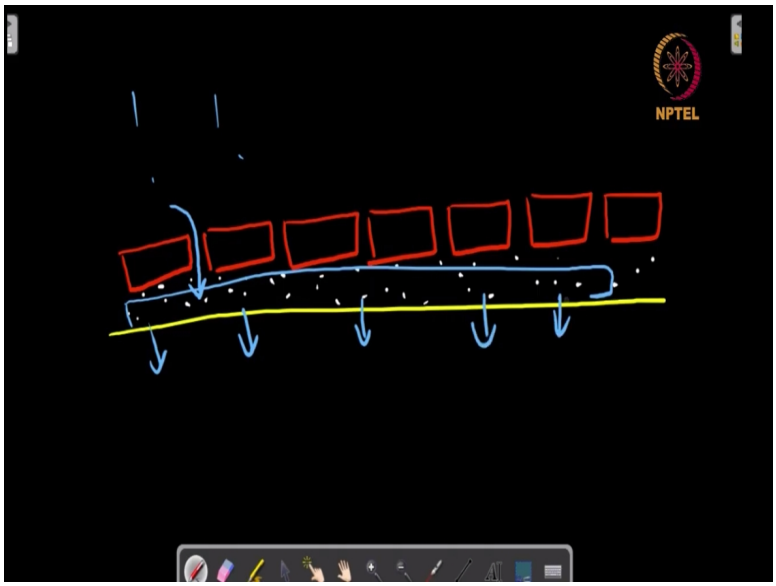

Now in the case of paving blocks what happens is that above the ground surface so if we went for concreting it would be a completely impervious layer of concrete that would be poured, but in the case of paving blocks a layer of sand is added to the top of soil and above this layer we put blocks which are made out of burnt clay.

So, these are essentially porcelain materials or in some cases we can even go with concrete materials. But the good thing is that these are small blocks which means that if there is rainfall then water can seep through these sides and here it has sand the so the sand is going to stop water for some time and permit this water to infiltrate down into the soil. So, that is the benefit of a paving block.

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Now, in this picture you can see that all of these area so this is again the side area this area so I am taking a picture from behind and here you can observe that all of these area is now paving blocks and on the side I left certain space for growing plants and these plants were planted. So, mostly these are Tulsi plants and any plant that was left over during construction. So, like this is a Saptaparni tree that was cut before this boundary wall was made.

And so when I arrived to the scene I found that there is a small stump and people were going to pull it off, but I said no, no, just let it be and if there is any life then this would prop up again and lo and behold, actually came up. So, now this tree is again growing back. Now the best thing about the paving blocks is that if there is any rainfall it will be move to the groundwater. It will not runaway as a surface flow.

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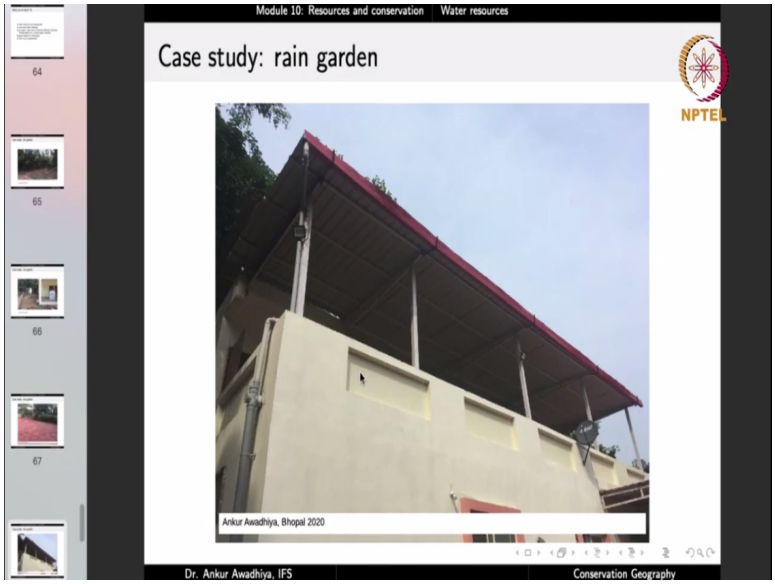

Another thing that I got constructed is this tin shade with the water harvesting. So, any water that falls on this rooftop is now moved back into the ground. If we look at the backside so here we are talking about this region. So, before this house was allotted to me all of these regions were suffering from a surface flow of water. So, whenever it rained because there is no vegetation to stop the rain flow. So, all of the water would just rush down.

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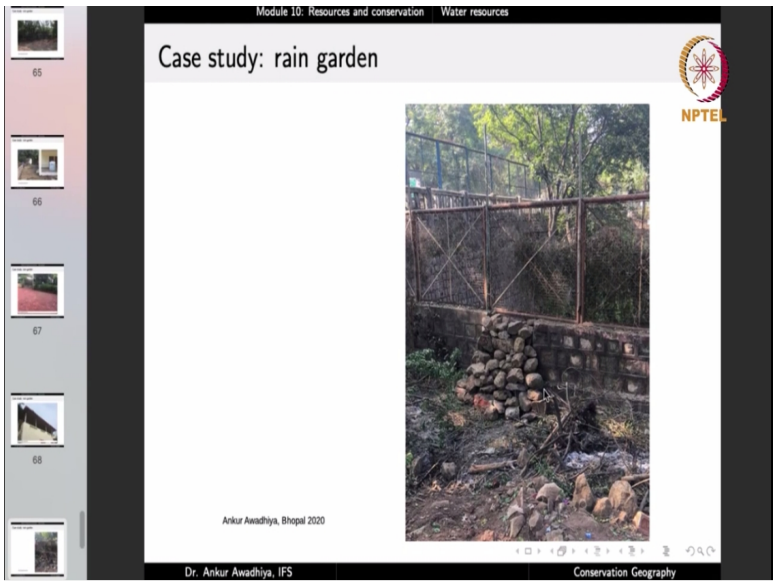

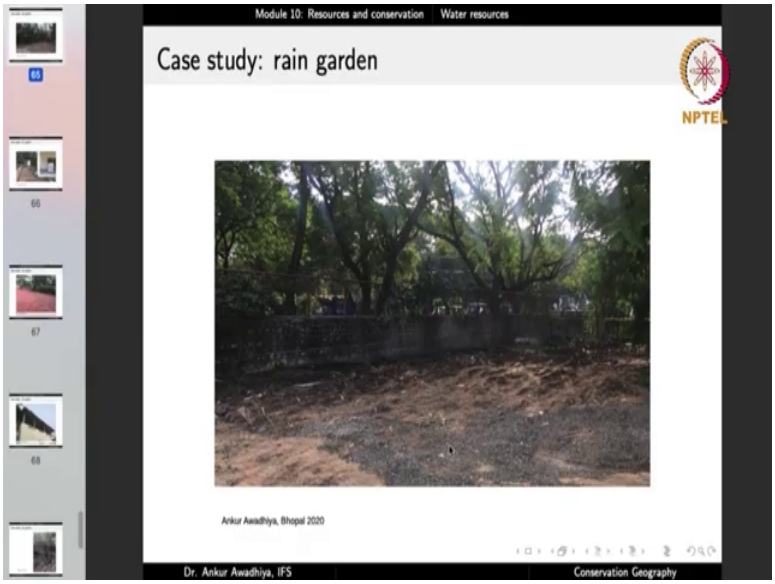

And so there was a space that was created so there was a big hole here on the boundary to allow for this water to move away. So, what I did was I got it covered with these small boulders so that the water is able to move away, but the sediments should be stopped here. Now thankfully even today we do not get water reaching to this point. Another thing that we got made here is that we dug trenches which are parallel to this direction. So, they are essentially perpendicular to the slope. So, similar to the concepts of contour farming.

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So in this case what was done is that if this is the slope then we constructed trenches like this. Now the benefit of such trenches is that the water which is flowing in this direction down slope it will get accumulated here. And so the speed reduces then when it overflows it will get accumulated here then it will get accumulated here. So, similar to the concept of contour

farming here again we are stopping the water and at every stage the water has to stop and when it stops the sediments are deposited here.

So, the soil will not be washed away the soil will get deposited in these trenches. So, this was another thing that was done. Yet another thing that was done was that when we talk about the grey water harvesting and the black water harvesting. So, the septic tanks were connected to the garden.

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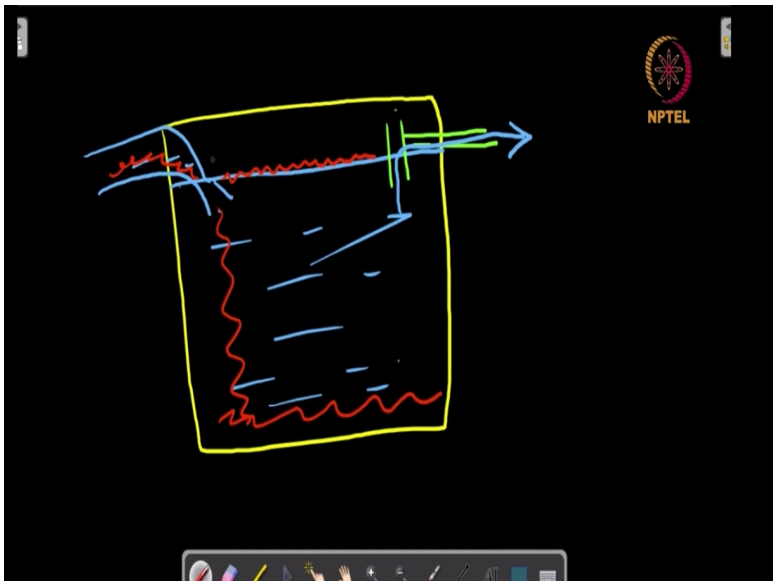

So, the way a septic tank works is that you have a large size tank which is covered and the sewage moves into this tank through a pipe and there is a layer of water that is maintained in the septic tank. So, in this case all the sewage will either move down to the bottom of the septic tank or it will stay here on the top as a sludge.

So, especially the oily components stay on the top. Next, the outlet is made like this. So, the outlet is like this. So, what it does is it maintains an air connectivity to the top. These oily and greasy portions cannot move out plus the water that is able to move out of this septic tank is the water from a depth. So, essentially you only get the treated water because of the solid components of sewage they move down they settle at the bottom.

The oily components float on the top and there is microbial degradation that is happening inside and only after microbial degradation is the water allowed out and this water was then shifted to the garden. So, this is the septic tank and the water was shifted to the garden and I

was allotted this house in the month of January and by the month of October this is the condition.

So, earlier the area that did not have a single blade of grass that area now is lush green. This is another image. So, now so many plants are growing here and some of these plants were planted. So, we took plants from nursery got them planted here, but most of the plants are the ones that grew up naturally because any area will be having certain amount of seed bank inside because there are a large number of seeds that are being brought to the area say through wind or through the dropping of birds and now these plants are coming up. They are the majority in this garden.

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And this is another view so now this is the backside this is the slope and now you find that these all of this area is now full of plants. Now these plants have changed the composition of the soil they have made it humus rich. They protect the soil against desiccation and against erosion and they make the rainwater move down into the soil.

So, you remember the plug that we had setup when we went to this plug in the rainy season there was no water that was flowing through the plug because all the water was being pushed into the ground because of these trees, these plants.

And constructing a rain garden is not difficult it is not expensive probably the only things that you need is to dig a small trench maybe plant a few plants otherwise they will come up on their own and direct your sources of waste water into that garden. Another benefit of a rain

garden is that it also treats the waste. So, the organic matter in the black water becomes humus in the soil.

The mineral matter in the black water becomes nutrients for the plants and so all these waste which otherwise would have moved into say a pond or a lake or into a stream that is now being used up by the plants. So, there are multiple benefits of a rain garden and we can use simple techniques like simple techniques like this to conserve our water resources. So, that is all for today. Thank you for your attention. Jai Hind!