Water Supply Engineering
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Lecture - 02
Water Sources and Availability

Hello friends, welcome back. So, in the first class for this course water supply engineering, we had a brief discussion about the general objective and content of the course and the importance and motivation behind the course. So, from this lecture onwards we are going to start the discussion on this specific topic and the first thing that we are going to discuss is the water sources and the availability of water.

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So if you see what we will be basically covering in this lecture, so we will be talking about generic water cycle okay. We will be talking about global water availability and distribution, so how much water is available and how it is distributed across different continents or states. Then we will be focusing on water availability in India separately. And then what are the spatial and temporal distribution of water in India and we will discuss about water stress and scarcity issues.

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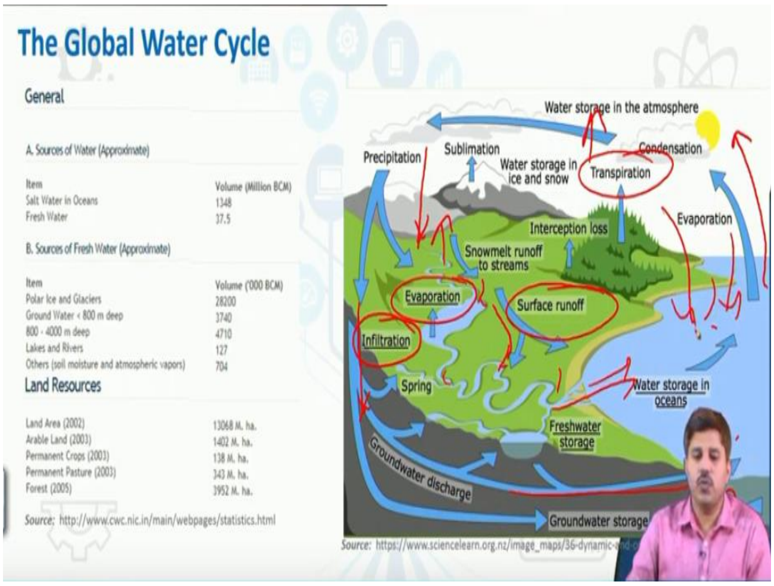

So, globally if you see, actually, I am sure this is my all audience would probably be aware with this that the water flows through different mediums in a cycle, okay. So we have since it is a cycle so there is no start point and end point, it is difficult to basically pick any specific start or end point. But as the ocean is the largest source and sink of the water probably so we can take ocean as a say start point and end point.

So what happens in a water cycle the water will evaporate from ocean okay and then it goes to the atmosphere. Then water will be stored in the atmosphere for some time and then it gets condensed there and comes back in the form of precipitation. And this precipitation could be in the form of rainfall or snowfall, okay. So, the water again will come back on the earth surface through precipitation.

Now, depending on where it falls, if it is directly falling in a water body it is there otherwise, if it is falling on say other land uses, so say paved area, greeneries or hills, rock wherever it is falling. So then there will be some loss through again evaporation and transpiration. So, if it is basically getting lost from greenery or those things it is transpiration or otherwise we call that evaporation or in jointly we call that evapotranspiration.

So evapotranspiration will again take back this water back to the atmosphere, okay evaporation and transpiration. There the water which falls on the earth will actually then flow depending on the slope wherever it is getting slope and it will eventually flow to some nearby river or lake or water body. So, that is your surface runoff component.

And then when it comes to the river let us say rivers again eventually connect to the sea or if it is comes in the pond and those things are still going to remain there for some time and eventually some of it might be evaporated back and some of it might be so, whatever falling on the earth will either be either will be lost through evapotransportation or will actually flow on a surface in the form of surface runoff or it can go to sub surface through infiltration.

So water can infiltrate below the soil, so that is infiltration component. Then it becomes a component of subsurface water or groundwater. And then groundwater is stored in the aquifers and eventually that will also be connected to the sea. So that way it is starting from the sea and again coming back to the sea either from the surface water sources or groundwater sources or through the atmospheric sources.

So whatever source we take, it eventually start from there and come back to the same point, okay. Majority of water it is a well known fact that majority of water is salt water which is available in the oceans and the sources of freshwater are actually limited.

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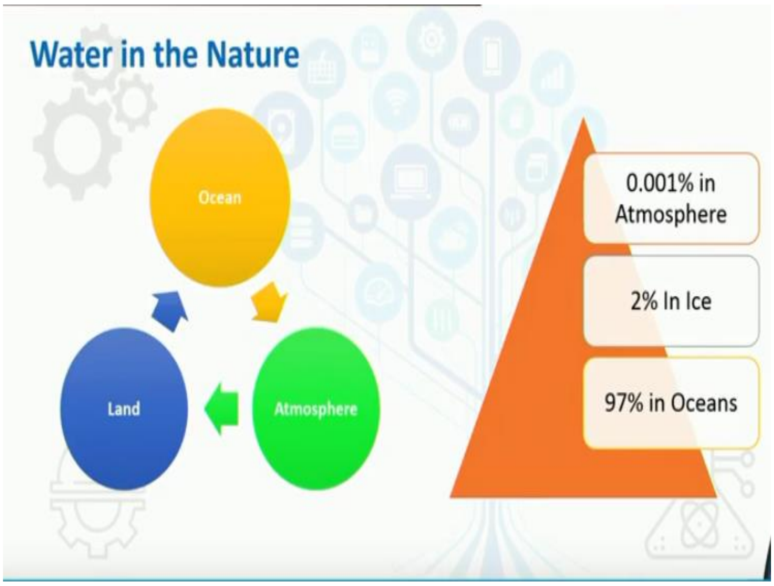

So if we see the total water available in nature, we have water available in the ocean, water available in the atmosphere and water available in the land, okay. Land it could be in the form of surface as well as subsurface, right. The majority are almost 97% or in fact, a little more than 97% is in the oceans. Then a large portion around is in the ice and very little water in the atmosphere.

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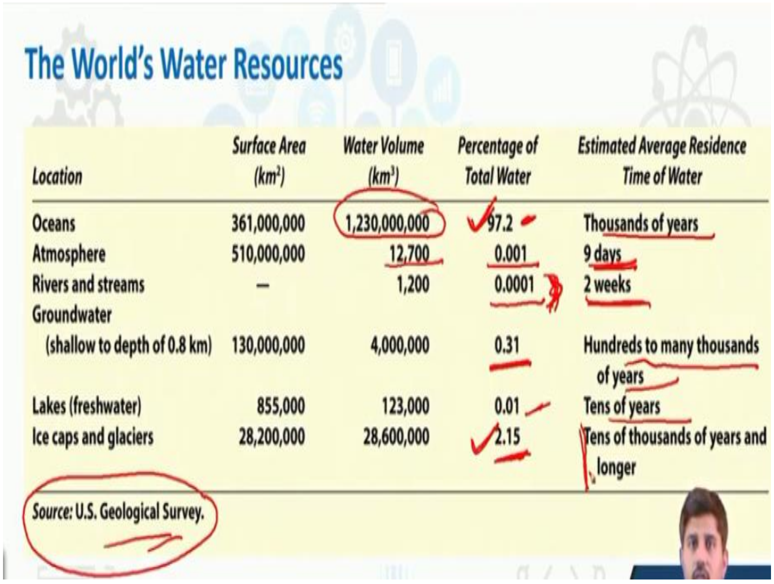

The World's Water Resources

Location	Surface Area (km^2)	Water Volume (km^3)	Percentage of Total Water	Estimated Average Residence Time of Water
Oceans	361,000,000	1,230,000,000	97.2	Thousands of years
Atmosphere	510,000,000	12,700	0.001	9 days
Rivers and streams	—	1,200	0.0001	2 weeks
Groundwater (shallow to depth of 0.8 km)	130,000,000	4,000,000	0.31	Hundreds to many thousands of years
Lakes (freshwater)	855,000	123,000	0.01	Tens of years
Ice caps and glaciers	28,200,000	28,600,000	2.15	Tens of thousands of years and longer

Source: U.S. Geological Survey.

So, if you see these numbers, the total volume of water available in the oceans is around this much okay, which is 1,230,000,000 cubic kilometers okay, which nearly makes 97.2% of the total water. So this data is from US Geological Survey, okay. There are different sources of such data and there is a there might be some fluctuation in the number.

Some claim it to be 97.5%, some claim it to be 97% but it is more or less in that range. So it is a basically United States Geological Survey data suggest that around 97.2% of water is in the oceans, okay. The atmosphere contains 0.001% of the water which is around 12,700 cubic kilometers. Then the rivers and streams contain very little, just 0.0001% of the water.

Now you see this is a very important component because most of us rely on this water in fact. There are ground waters, which is again around 0.31%. The next largest, like this is the most prominent and most significant portion of the water, the ocean water. The next largest component is ice caps and glaciers which holds around 2.15% of water.

Then there are freshwater lakes and those which also has water of around 0.01%. So the water lies in different locations. And as just we were discussing that there is a cycle through which water flows from one portion to the other or one location to the other location. So, there is a a average residence time that water spends in these locations.

So like if some fraction or some portion of water is going into the ocean, so it nearly takes almost thousands of year for that water to get to atmosphere from the ocean. So, the average residence time or estimated average residence time in the ocean is very high, around thousands of year. The shortest residence time of water is in atmosphere so it spends an average of 9 days in the atmosphere, okay.

Of course, it does not mean that 9 days is a fixed value. It is just an average number and that to estimate. So the water which is getting evaporated to the atmosphere, it usually stays for there in about 9 days or average time period of 9 days. And then it again falls back through the precipitation. The water in the river and streams could take around 2 weeks. So there are waters, there are river and streams which connect to the ocean just in 4, 5 days. There are rivers which takes much longer period.

So average residence time in the rivers and streams is about 2 weeks. The groundwater also is stored for a much larger period. So water that is going to the subsurface or in the aquifer may remain there from hundreds to many thousands of year. Now, this varies a lot because it depends on where the water is stored. It is in the shallow groundwater.

It means are we talking about the shallow groundwater or shallow aquifers or we are talking about the deep aquifer. So, the water that goes into the deep aquifer, it takes a lot of time for that water to move to the sea. The water in the shallow aquifers have relatively shorter life period. Then in lake it may remain for tens of years. The kind of one of the most again longest residence time for water is in the form of ice caps and glaciers.

So the water that actually goes to the glaciers or the ice caps that can remain there for tens of thousands of years or even longer, okay. So that way the different like locations for the water stores water for different times and then the water moves from one location to the other. So the age of water again that way because since it is processed through a different locations, so the age, the quality, the characteristic of water also changes. The water which is in the ocean is saline.

The water, same water when it evaporates so salt does not evaporates, it is the water that evaporate. So that water that goes to the atmosphere is probably one of the purest form of the water because it has been there, it has gone there through a evaporation process, and it is just pure water molecules which has evaporated. In the atmosphere, it may interact with certain contaminants or certain pollutants, that is a different thing.

But otherwise, generally, the quality of water in the atmosphere is very good. And that is why we perceive that whatever the rainfall we are receiving is of very good quality, okay. And then it comes to the surface. So when it comes to the surface, it will acquire certain other type of pollutant or contaminant. There is sediment, salts, those kind of things will be added.

Then the water which goes to the groundwater, groundwater will have different quality so that way, the water in these different like ice caps it is just in the form of ice, solid form.

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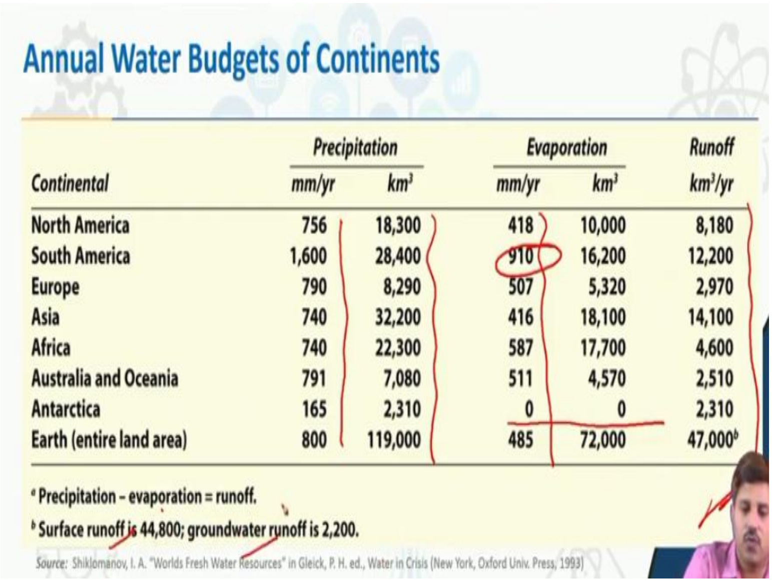

Annual Water Budgets of Continents

	Precipitation		Evaporation		Runoff
Continental	mm/yr	km^3	mm/yr	km^3	km^3/yr
North America	756	18,300	418	10,000	8,180
South America	1,600	28,400	910	16,200	12,200
Europe	790	8,290	507	5,320	2,970
Asia	740	32,200	416	18,100	14,100
Africa	740	22,300	587	17,700	4,600
Australia and Oceania	791	7,080	511	4,570	2,510
Antarctica	165	2,310	0	0	2,310
Earth (entire land area)	800	119,000	485	72,000	47,000[b]

[a] Precipitation – evaporation = runoff.
[b] Surface runoff is 44,800; groundwater runoff is 2,200.

Source: Shiklomanov, I. A. "Worlds Fresh Water Resources" in Gleick, P. H. ed., Water in Crisis (New York, Oxford Univ. Press, 1993)

So that way the different zones or different sections will have different characteristic of the water and they store water for a different time period. If we see the annual water budget of the continents, so then we can see that there is different like scale of precipitation that happens, okay in say millimeter per year and if we multiply it with the area of the continent, we get the total water.

Then the range of the evaporation is different from different places, okay. Of course the dryer portions will have very high evaporation. The portion where there is temperature is very low, we would not see much of the evaporation okay. Like Antarctica there is no evaporation losses, almost negligible evaporation losses. Whereas if you go to the South America part, the evaporation is quite high, okay.

And then from the precipitation if you sort of remove this, so the kind of runoff that is generated, so we will have the runoff estimation which is actually done from the precipitation and runoff, precipitation minus evaporation and this is a modeled system because eventually there will be some infiltration and those kind of thing. So that is to be considered and here the runoff considers both surface runoff as well as groundwater runoff means what is going through the infiltration.

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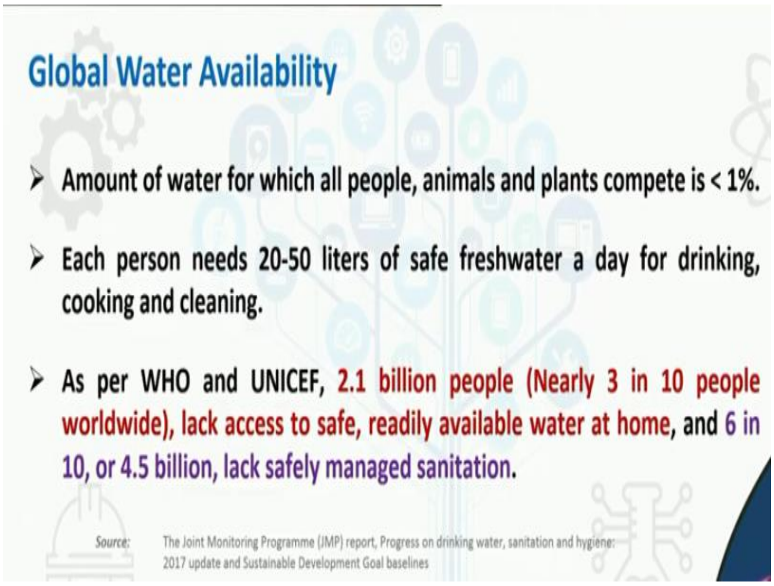

So, if we see about if we see the water available on a global scale so, as just we were seeing, 97 or little more than 97% of water is in the oceans. Then around a little more than 2% water is in the form of the ice caps and glaciers. Now, this are the portions of water which are largely unavailable for uses. The ocean water is saline, okay, directly not usable.

And similarly the ice caps and glaciers are stored in a far off places, there is not much population or civilization activities around those places. And moreover anyway if you want to use that water you will have to transport it, then put a lot of energy in order to make it in the usable form. So, practically that is also an unavailable source. So 97.2 plus 2.15 makes it a 99.35.

So practically that much portion of water is not available. We do use sea water for small applications using desalination and those things but that is actually negligible fraction, okay. So, we can safely assume that this much portion of water is not available. So the remaining water which is there in the rivers, streams, groundwater and lakes, those places so that is what is available for uses by the people, animal, plant, everybody.

So, all of us are competing for the water which is actually less than 1% of the total available water on the planet, okay. So that is the situation. Now, each person needs minimum 20 to 50 liter of safe fresh water in a day for drinking, cooking, and cleaning purpose. And as per WHO and UNICEF around 2.1 billion people, which is nearly 3 in the 10 people worldwide lack the access to this much amount of water.

So they lack the access to safe, readily available water at home and 6 in 10 or around 4.5 billion people lack safely managed sanitation.

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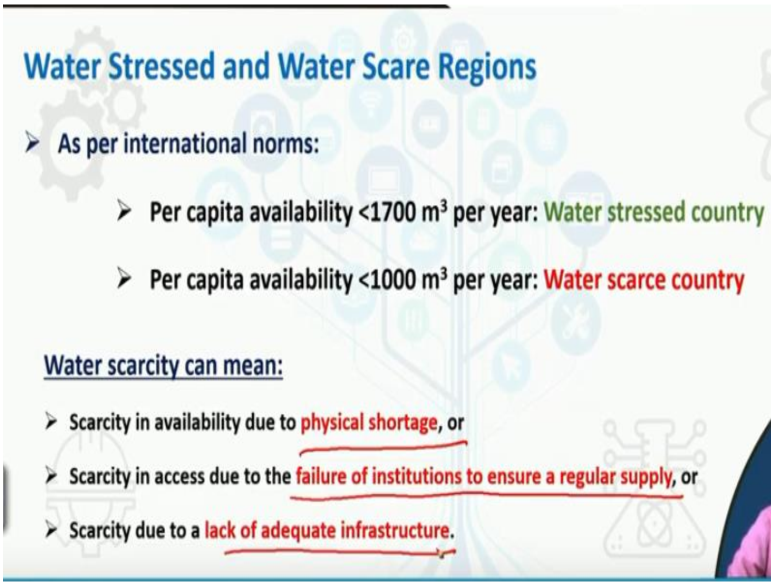

So this is the kind of situation. Since we have been discussing about the availability, so as per the availability the different reasons are categorized as water stressed or water scare reasons. So, as per the international norms, if the per capita availabilities above 1700 meter cube per year, we call that say from water perspective or water availability perspective, but if it is less than that, we call that country or that region as water stressed.

Then if availability falls below 1000 meter cube per year, we call that as water scare region or water scare country. Now, this water scarcity or in fact, water stress also can be of different types or like if we see the water scarcity, so water scarcity can be because of availability due to physical shortage. So we do not have substantial amount of water available. It could be scarcity in the access due to the failure of institution to ensure a regular supply.

So even if there is water, but the institutions or the system or the administration is not sound enough to make that water to ensure a regular and good supply. And it could be scarcity due to lack of adequate infrastructure okay. So, there could be the different reasons for this water scarcity.

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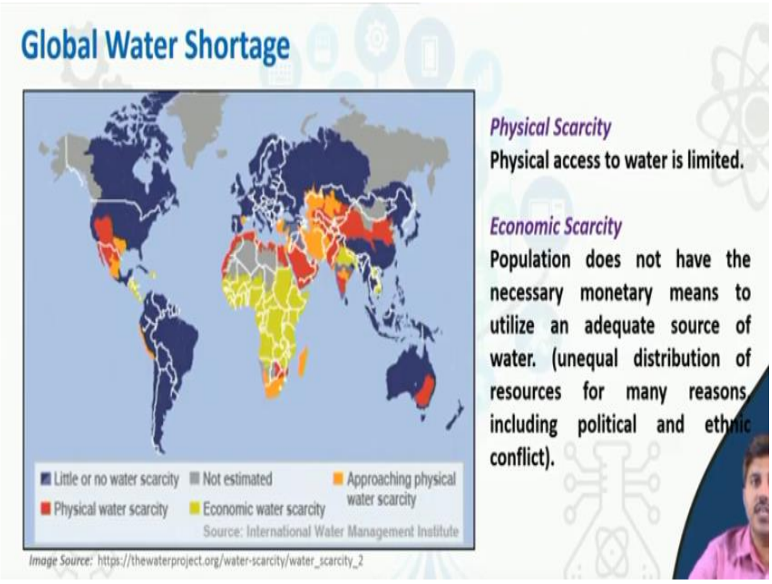

Now, if we look at the water shortage from global perspective, okay, so if you see the map here the blue portion indicates little or no water scarcity okay. So, a large portion of this and this are practically safe in terms of water. The red portion indicates the physical water scarcity, means there is a physically shortage of water, okay. So you can see that there is a lot of area towards in the eastern side, China, part of India, African countries, part of Australia. So all these are under physical water scarcity.

The orange portions are approaching physical water scarcity. So basically these portions that will be even if it is not physically water scarce, they will go into the physical water scarcity zone in due course of time. And this green one is basically the economic water scarcity, means even if water is available, it is there is no proper system to ensure the supply of the water.

So physical scarcity means physical access to the water is limited and economic scarcity means there is unavailability of necessary monetary means to utilize a water source okay, which could be for several reasons, including the political and ethnic conflicts.

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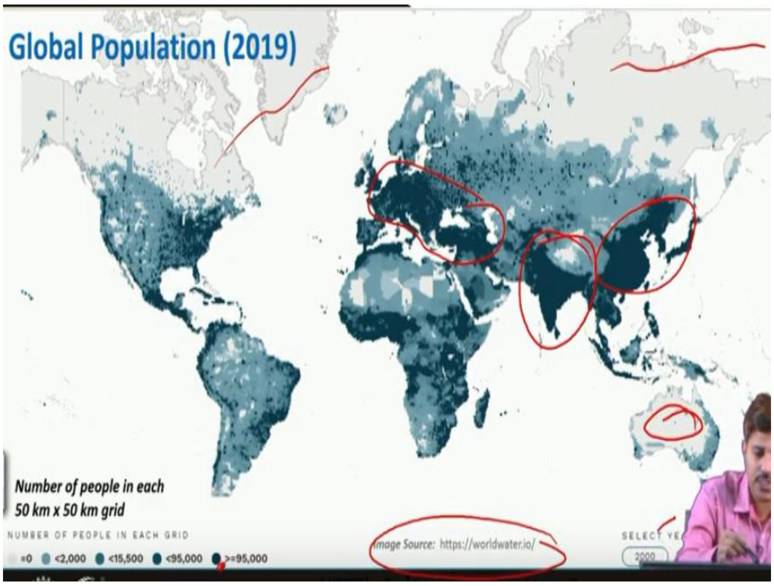

Now, this is a recent estimate actually which is available on the website, this. If you want you can go and have a look at it, this is a interesting observation. So, if you see the global data, it is basically available for several years 2000, 2010, 2019, and 2030. 2030 is estimated actually. So, this is the current data, this is what is actually selected here.

So it says number of people in a 50 by 50 kilometer square grid, okay. So it is basically how dense the population is spread over or worldwide. So this is about the population, okay. These portions indicates almost zero population, okay. The light shades less than 2000 and the darker one is less than 15,500. Further darker one less than 95,000 and the most dark one is actually greater than 95000 people in a 50 into 50 square kilometer grid.

So easily we can see that India is the one of the like having highest population density. So is this region, so is this region. So the population density in these regions is quite high whereas US is probably it is in a moderate range. Some of the African places very moderate, some places very high, okay. Australia, we can see that the like civilization has been around the periphery not much in between, okay. So this is what is basically the population data, okay.

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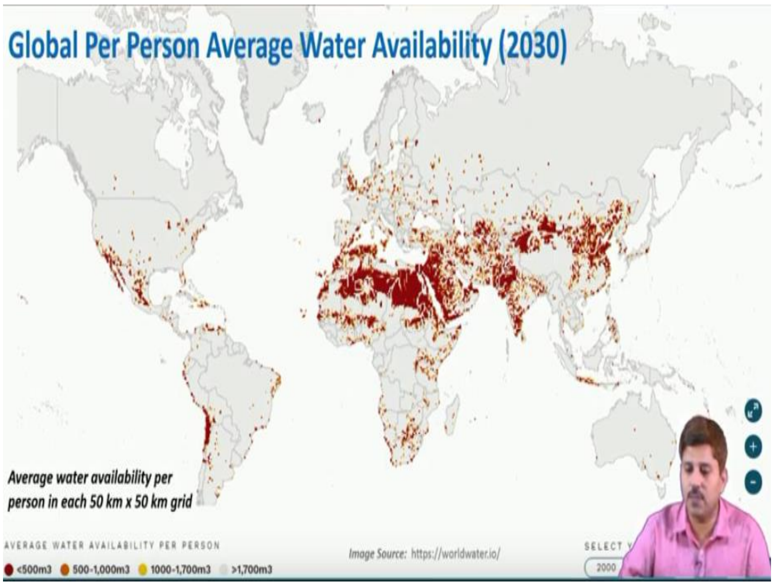

Now, the same setup, if we choose the average water availability, so the red portions you see here is basically the portions with water availability less than 500 meter cube. Again its availability per person okay and then the lighter one 500 to 1000. The yellow one 1000 to 1700 and the white one is greater than 1700. So basically this is means they are not under water, any sort of water scarcity okay or water stress. The yellow one are the portions in the water stress.

So there are various patches of yellow in and around these image which might not be prominently visible, but there are. And then there are dark patches which has very little water. So some portions in the Africa or some portions in the India, China, so India and China and Africa are probably the worst placed in this. Again this is a 2019 data. Now, same thing like this is 2019 figure.

Now, if you in the next slide we are going to see this is the 2030 estimates. So the earlier one previous one, this one is 19 and this one is 30. So you can see how the like zones are changing or some of the scarcity is increasing. So on the same map, you see this is 19 and just next. So there are prominently dark phases appearing here and here. So more water scarcity or lesser water availability per person is expected as we move in the future.

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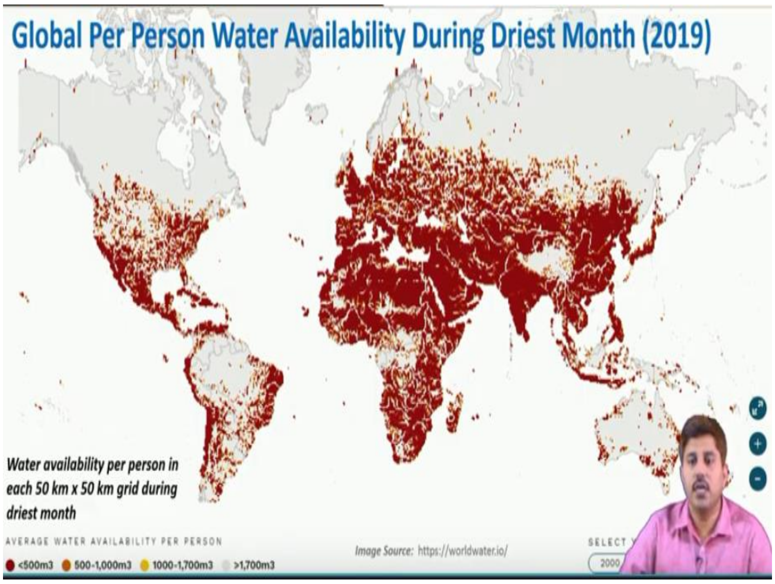

Now, this is global per person water availability during the driest month. It is important because what we were just seeing earlier is an annual average, okay. So how much like based on the total water available in a year how the water is available to the people but what happens let us say India, which is a monsoon fed country, so there is a lot of water available during the monsoon period.

But when we go to the dry season around say, February, March or those seasons there is very little water available okay. So this is the global water availability during the driest month in whichever could be driest month for India it is say February, March. Some other places it could be the different month which is the driest month depending on their rainfall pattern.

But there are going to be some time when which is a kind of the driest period and water available is very little in that period. So for driest if we see for the driest month, almost you can see that majority of the world, majority of the world actually have at some time when the water availability per person is in fact less than 500 meter cube. So we are actually in that region. Again, this is for 2019 data, if we move ahead it is going to be more scarier.

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So there is a national water stress ranking available from the World Resources Institute and they have ranked the different countries based on the water stress. So lot of Middle East countries like Saudi Arabia, Qatar, then UAE, so those countries are basically featuring most prominently in the extreme high baseline water stress regions. India is also there ranked at 13 number okay.

So we are also there in the extreme high baseline water stressed countries. Then there are a group of high baseline water stressed countries, okay. So some of the European and Eastern another various Eastern countries are there, okay. European countries like Spain, Italy, those kind of countries are also there. Then there is a medium high baseline water countries.

Again, a lot of other prominent countries including Australia, China, Germany. France, okay, Thailand, Sudan. So they all, Indonesia, they all feature they all come in here. And then there are low and medium baseline water countries. So there is another list of around 50, 60 more countries, which are low baseline water stressed countries, okay. So this is the data compilation from the World Resources Institute, okay.

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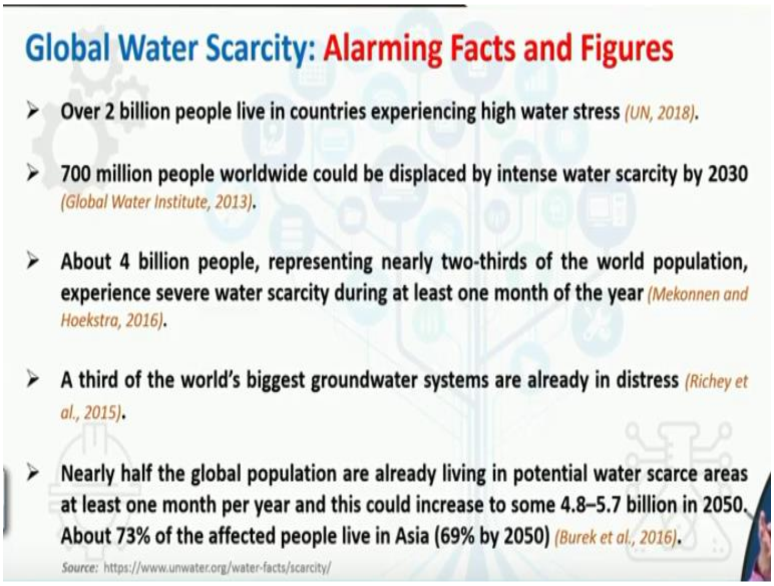

Now, if we see the global water scarcity, there are certain alarming facts and figures, mostly from United Nation. So it is all available on the United Nations websites from where it has been sourced. So there are around over 2 billion people live in countries that experience high water stress. So that is a huge population, okay 2 billion people means 2000 million people are actually living in the countries that are experiencing high water stress, okay.

There are 700 million people worldwide which could be displaced by intense water scarcity by 2030, okay. There are around 4 billion people, which represents almost two third of the world population, okay. They experience severe water scarcity during at least one month of a year. So as just we were discussing actually there is a, there could be a period when the water is at lowest, water availability at lowest levels or driest month.

So if we look at the driest month, around two third of the world population is in the water, kind of experience water scarcity at least during one month in a year, okay. Almost one third of the world's biggest groundwater systems are already under stress. So that is another data. There is a huge talk or concern about the groundwater depletion. And this in fact tells the real picture.

Again nearly half of the global population are already living in the potential water scare areas and at least one month per year. Now, this could increase to 4.8 to 5.7 billion in 2050, which will be about 73% of the population.

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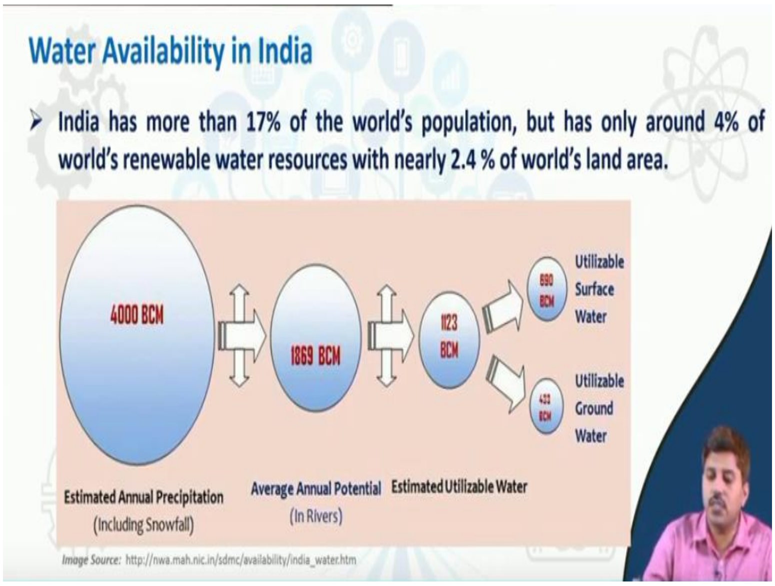

So that way we can basically see that what are the situations that we are living in. Now, if we talk about water availability in India, so India has around 17% of world population but only around 4% of the renewable water resources, okay. Land area we have even less, that is why the highest like one of the highest population density in the world. So we are actually like just 2.4% of the land area and we are holding over 17% of the world's population, okay.

Now the total annual precipitation or estimated annual precipitation is 4000 billion cubic meters okay which is equal to kilometer cube anyway. Of this, the average annual precipitation that goes to the river is 1865 billion cubic meter. Again, the estimated utilizable water in the rivers is 1123 means of the total precipitation actually not only in the river is actually 1123 billion cubic meters.

The utilizable surface water available in the different river basins is around 960 sorry 690 billion cubic meter and the groundwater is around 433 billion cubic meters.

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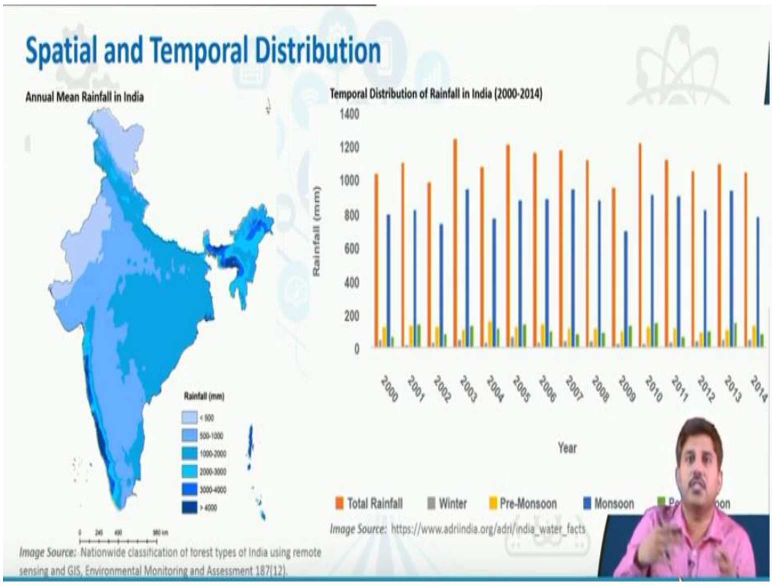

So these are some rough estimate. Now if you see the spatial and temporal distribution of the water that we get in the India, so, there are portions where the like this is a annual mean rainfall. So there are patches where we have high mean rainfall of the order of around 3000 to 4000 or even higher mm. So you can see some portions in the northeast and the western corridors okay there are the high rainfall.

Then there are places of rainfall around say like the most more prominent area have rainfall around 1000 to 2000 mm okay. There are other areas where rainfall is substantially less, less than 500 or so particularly the northern side okay and part of the central has lesser rainfall, okay. The coastal boundaries, coastal areas has the highest rainfall and some of the Northeast Cherrapunji and all that falls here.

So they have a good amount of rainfall. If we see the temporal distribution, so this is actually across from 2000 to 2014. For all the different years this has been the total rainfall. So you can see that how the total rainfall varies, okay. Then there is a rainfall in the winter season, almost negligible. You can see the small blocks here, okay. Then pre-monsoon period rainfall, these yellow blocks.

So there is some rainfall during the pre-monsoon. It is the monsoon season that has the highest rainfall, okay. So the blue which is you will see just little lower than the total rainfall. So they are the during the monsoon and some rainfall we have in the post-monsoon season as well. So in some years you can see that post-monsoon is very prominent very high okay.

While in some years you can see that post-monsoon rainfall is very low, okay. So like you see 2010 and 11 there is significantly high post-monsoon rainfall, whereas low and this has led to the difference in the average annual rainfall as well. So we have sort of spatial as well as temporal distribution of the rainfall, different states, different parts of the country gets different level of rainfall and so happens with a different time period.

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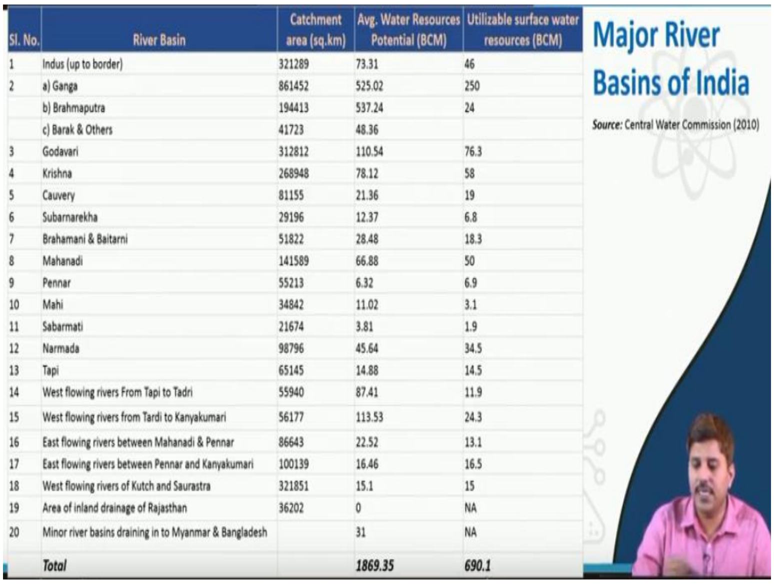

Sl. No.	River Basin	Catchment area (sq.km)	Avg. Water Resources Potential (BCM)	Utilizable surface water resources (BCM)
1	Indus (up to border)	321289	73.31	46
2	a) Ganga	861452	525.02	250
	b) Brahmaputra	194413	537.24	24
	c) Barak & Others	41723	48.36	
3	Godavari	312812	110.54	76.3
4	Krishna	268948	78.12	58
5	Cauvery	81155	21.36	19
6	Subarnarekha	29196	12.37	6.8
7	Brahamani & Baitarni	51822	28.48	18.3
8	Mahanadi	141589	66.88	50
9	Pennar	55213	6.32	6.9
10	Mahi	34842	11.02	3.1
11	Sabarmati	21674	3.81	1.9
12	Narmada	98796	45.64	34.5
13	Tapi	65145	14.88	14.5
14	West flowing rivers From Tapi to Tadri	55940	87.41	11.9
15	West flowing rivers from Tardi to Kanyakumari	56177	113.53	24.3
16	East flowing rivers between Mahanadi & Pennar	86643	22.52	13.1
17	East flowing rivers between Pennar and Kanyakumari	100139	16.46	16.5
18	West flowing rivers of Kutch and Saurastra	321851	15.1	15
19	Area of inland drainage of Rajasthan	36202	0	NA
20	Minor river basins draining in to Myanmar & Bangladesh		31	NA
	Total		*1869.35*	*690.1*

These are the major river basins of the India. So there are basically around 20 river basin, which is recognized as a major river basin okay. And the catchment area of all those river basins and then the average annual rainfall and utilizable surface water which eventually comes to 690 as we were just seeing in the previous slide.

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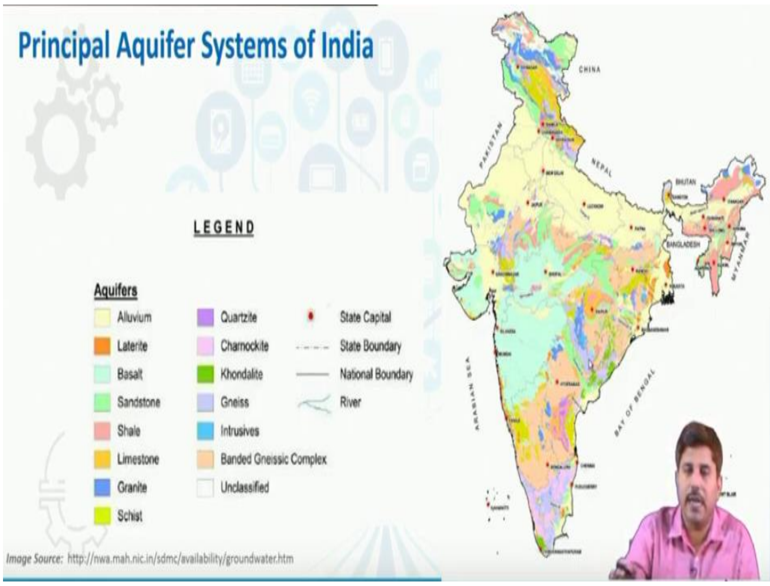

If we see the aquifer systems of India, so we have different kind of aquifers; alluvium, laterite, basalt, so depending on what kind of aquifer system is there and this is how it is spread in the India. So this map kind of explains the spread of the different aquifer systems in India.

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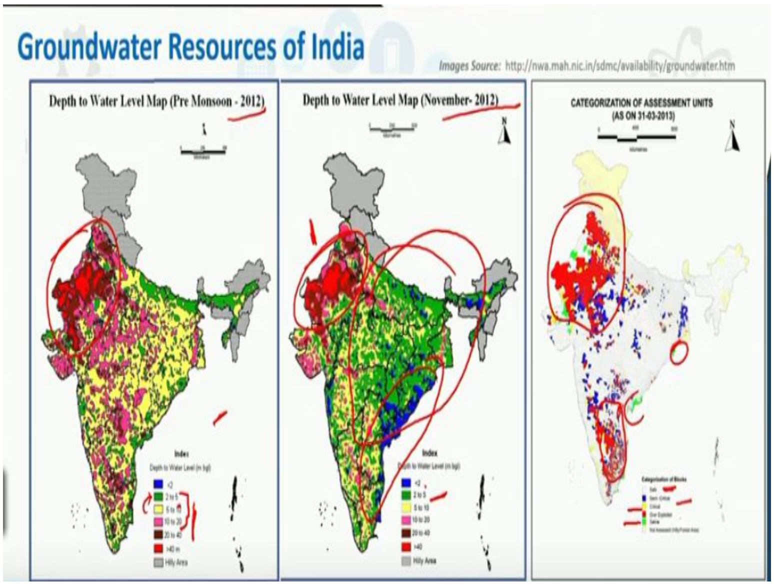

Now if we talk about the groundwater resources, so you see this is the depth of water level map in the, this portion is the depth of water level map during a pre-monsoon period. Now you can see that during pre-monsoon period, the major portions depth of the water level is actually from falls in this category. So more so ever in fact not even the green, it is mostly the orange, mostly the like yellow and then this color.

So most places it is actually like 5 meter or deeper, 5 to 20 meter and some patches it is actually even deeper. But after the monsoon, so this is actually pre-monsoon period and same year after the monsoon what happens that you can see that most of the yellow has converted to green. So we will see a good green patches over here so the groundwater is actually within the like water table is within the 2 to 5 meter range.

Some portion has turned green, so the water table is actually less than 2 meter, more so ever in the coastal area or the area of high rainfall. Whereas, this portion still have high ground water depth. Anyway rainfall is also very little in this region if you see. So eventually if you categorize based on this thing, so you can say that like the white part or the gray part is more or less safe. The blue part is semi-critical.

The yellow part is critical. The red part is over exploited okay and the green part is saline. Of course, some coastal belts are saline but apart from that you can see that there is a lot of red part in the Punjab and those regions, which is actually over exploited region and some of the south central portion. Then there is some semi-critical portions, the yellow here and there and then there are some like is critical and semi-critical portion but majority part otherwise remains in the safe region, okay.

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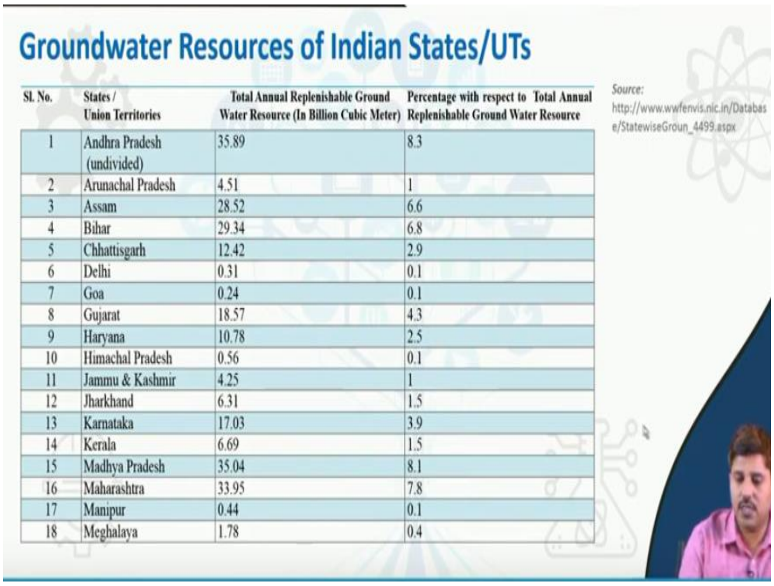
Groundwater Resources of Indian States/UTs

Sl. No.	States / Union Territories	Total Annual Replenishable Ground Water Resource (In Billion Cubic Meter)	Percentage with respect to Total Annual Replenishable Ground Water Resource
1	Andhra Pradesh (undivided)	35.89	8.3
2	Arunachal Pradesh	4.51	1
3	Assam	28.52	6.6
4	Bihar	29.34	6.8
5	Chhattisgarh	12.42	2.9
6	Delhi	0.31	0.1
7	Goa	0.24	0.1
8	Gujarat	18.57	4.3
9	Haryana	10.78	2.5
10	Himachal Pradesh	0.56	0.1
11	Jammu & Kashmir	4.25	1
12	Jharkhand	6.31	1.5
13	Karnataka	17.03	3.9
14	Kerala	6.69	1.5
15	Madhya Pradesh	35.04	8.1
16	Maharashtra	33.95	7.8
17	Manipur	0.44	0.1
18	Meghalaya	1.78	0.4

Source: http://www.wwfenvis.nic.in/Database/StatewiseGroun_4499.aspx

The total groundwater resources of various Indian state and Union Territories are sort of classified by or assessed by the Central Groundwater Board. So these are CGWB data. They have compiled state wise. So what is the total annual replenishable groundwater resources, in billion cubic meters and what is the percentage with respect to the total replenishable groundwater resources?

So you can see that there are states with varying percentage like Andhra has around 8.3%, which is undivided Andhra in fact including Telangana has around 8.3% share, okay. Other major are MP, Maharashtra. So they have prominent share of the total groundwater, okay.

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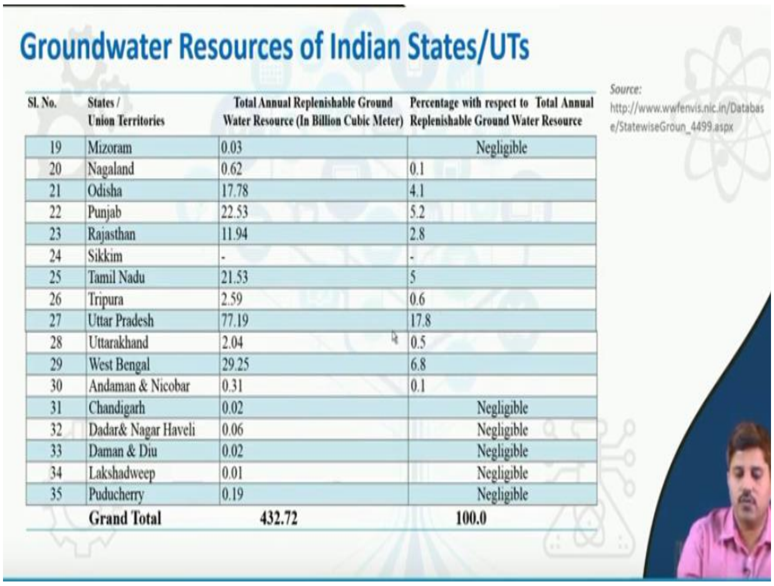

Groundwater Resources of Indian States/UTs

Sl. No.	States / Union Territories	Total Annual Replenishable Ground Water Resource (In Billion Cubic Meter)	Percentage with respect to Total Annual Replenishable Ground Water Resource
19	Mizoram	0.03	Negligible
20	Nagaland	0.62	0.1
21	Odisha	17.78	4.1
22	Punjab	22.53	5.2
23	Rajasthan	11.94	2.8
24	Sikkim	-	-
25	Tamil Nadu	21.53	5
26	Tripura	2.59	0.6
27	Uttar Pradesh	77.19	17.8
28	Uttarakhand	2.04	0.5
29	West Bengal	29.25	6.8
30	Andaman & Nicobar	0.31	0.1
31	Chandigarh	0.02	Negligible
32	Dadar& Nagar Haveli	0.06	Negligible
33	Daman & Diu	0.02	Negligible
34	Lakshadweep	0.01	Negligible
35	Puducherry	0.19	Negligible
	Grand Total	432.72	100.0

Source: http://www.wwfenvis.nic.in/Database/StatewiseGroun_4499.aspx

And these are like some of the other state. UP has the most prominent because around 18% of the total groundwater share is reserved by the UP.

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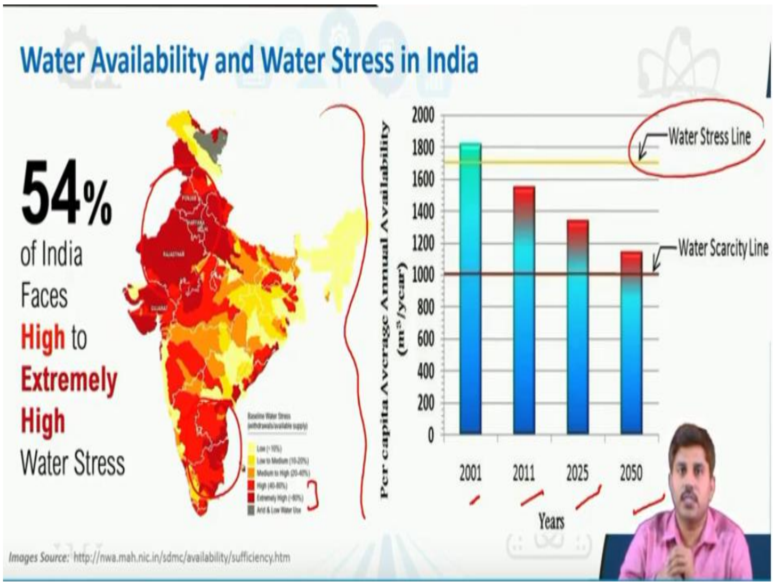

Now if we see the water availability and stress conditions in India. So as we discussed on a state wise you can see that like lot of states are in the high to extreme high zones, particularly this Rajasthan, Punjab that belt, okay and some southern part, southern eastern part also has basically that kind of high stress and various other portions have sort of low to medium stress in terms of the groundwater availability, okay.

The per capita availability again in 2001, actually when India became independent in around 1947, we had close to 6000 meter cube of water per capita, but that has constantly been declining. In 2001 we had around 1800. In 2011 we are less than 1600. 2025 it is expected to be less than 1400 and by 2020 we are expecting around 1100 or 1150 by 2050.

So we actually crossed already water stress line and that is the reason that you see all places are probably having some sort of or majority of the places having some sort of water stress and we are approaching towards water scarcity as well as a whole nation although some parts are already under very high water stress or water scarcity, but as a nation we are approaching towards this and one of the major reason for this is the population growth because the population is growing.

So resources are same, so per capita availability is declining. So with this we conclude the discussion on the water availability, okay. We did see how water is distributed across the globe in different countries and how much water we get in India. What are the storage capacities of our river basins. What are the capacity of the water to yield capacity of our river basin to yield the water for utilization purpose.

What are the capacity of the groundwater or our aquifer systems. So and what basically where we exist right now in terms of the water scarcity levels. So we will conclude this discussion and in the next class we will talk about the water uses. So we have been talking about water availability, how much water is available to us. Now we will discuss in the next class, what are the different classes or sectors for water uses.

How much water is used into the different sectors and what are the kind of key drivers for changing the pattern of the water uses in the different sector. So see you in the next class. Thank you for joining. Have a great time.