Watershed Management

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Module No. # 03

Lecture No. # 10

Rainwater Harvesting System

Welcome to the video course on, watershed management in module 3, lecture numbers 10. we will discuss today, rainwater harvesting system.

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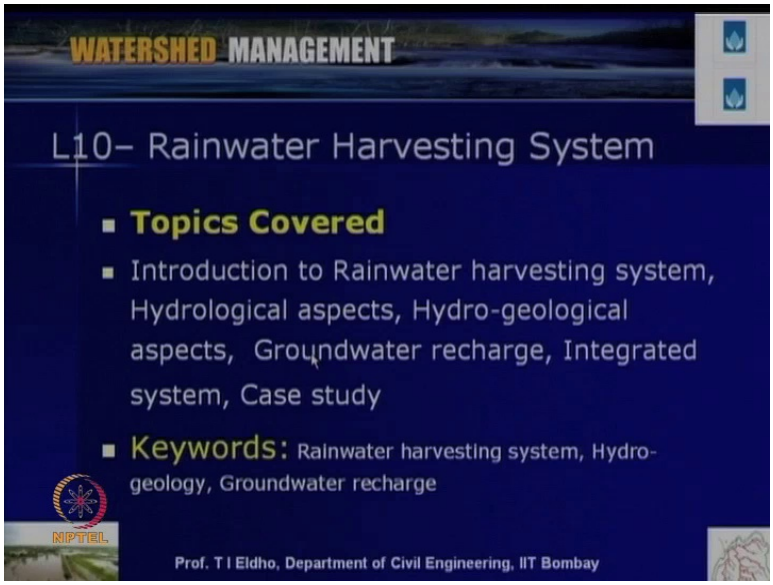

Some of the important topics covered in today's lecture include introduction to rainwater harvesting, hydrological aspects of rainwater harvesting, Hydro-geological aspects, groundwater recharge and integrated system for rainwater harvesting, then a case study. Some of the certain keywords in today's lecture include rainwater harvesting system, hydro-geology, ground water recharge.

We are discussing about the watershed management and we have seen that the water availability and then related water resource issues, are major issues as far as the total development plan of a watershed. That way water is one of the most important issues, as far as the watershed development plans are concerned. Water, we are getting mainly through rainfall. And this water says, as we have already seen say convert to run off and then so, many losses take place. And in the hydrological cycle, this water will be transformed from one form to another form.

The main purpose of this rain water harvesting is, to obtain the water wherever it falls. Say for example, in a watershed on a watershed basis say, see the rainfall takes place in that particular area. We want to capture that rainwater in that particular area and then utilize. That is the basic concept of rainwater harvesting.

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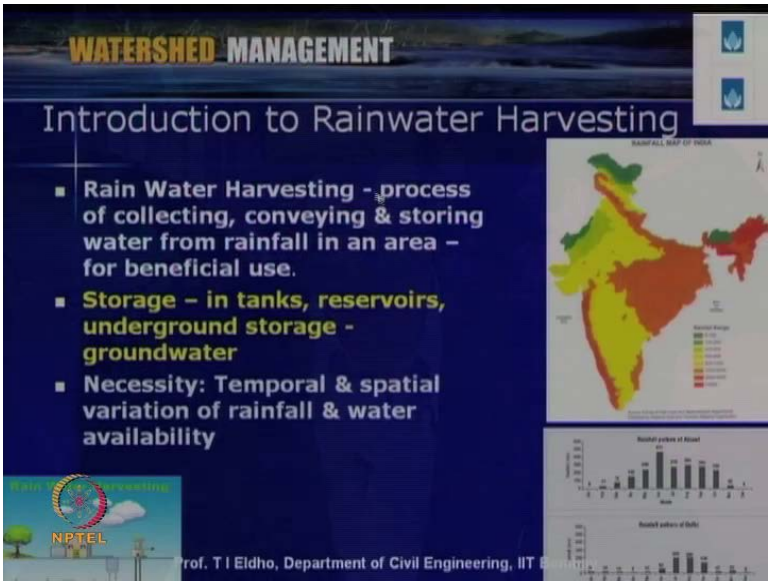

That way we can define the rainwater harvesting say, process of collecting, convey and storing water from rainfall in an area say, for beneficial use. The use can be either domestic purpose agriculture purpose or any other purpose. Generally, the storage can be in tanks or in reservoirs or like an underground storage like groundwater. We have already seen that say for example, if you consider country like India; we have say the rainfall variation is too much. Say like the rainfall is there mainly in the monsoon season and that is mainly three, four months starting from June to September or October and the variation is also spatial.

We can see that, if you consider this rainfall map of India, in some locations the rainfall is more than 200 centimeter per annum and even some location, it is more than 4000 millimeter, 5000 millimeter. And in some locations, the rainfall is say to the tune of 20 centimeter or 200 mm or less than that. That way spatially, the rainfall availability is varying from one location to another location. So, that way the available water resource, the available rainwater we have to utilize in an effective way. So, that way rainwater harvesting is very much essential.

The necessity of rainwater harvesting is due to mainly temporal and spatial variation of rainfall and the water availability. If you consider say for example, the rainfall pattern in ice wall and then rain fall pattern Delhi. you can see that the rainfall in a ice wall, it is almost say it is about more than eight months and the variation is say good distribution is there. But in Delhi, you can see that mainly the rainfall is only for three months and average rainfall is about 700 mm per year. So, that way the rainwater harvesting is very important. Wherever, the rainfall takes place we want to harvest it and then we want to use it, especially in that particular location or particular watershed which we consider.

When we consider the rainwater harvesting this say, now these are rainwater harvesting has been used by our forefathers for centuries. But due to the recent negligence of this rainwater harvesting say for last few decades. In many locations we have got lot of water related problems. So, that way rainwater harvesting say not a new technology, but a forgotten technology which we have to now revises on a large scale. So, that way rainwater harvesting we can define to say, technology used for collecting and storing rainwater from roof top lands, surface or catchments or say watershed basis using various techniques, such as tanks or check dams or recharge to the aquifer system, as we discussed.

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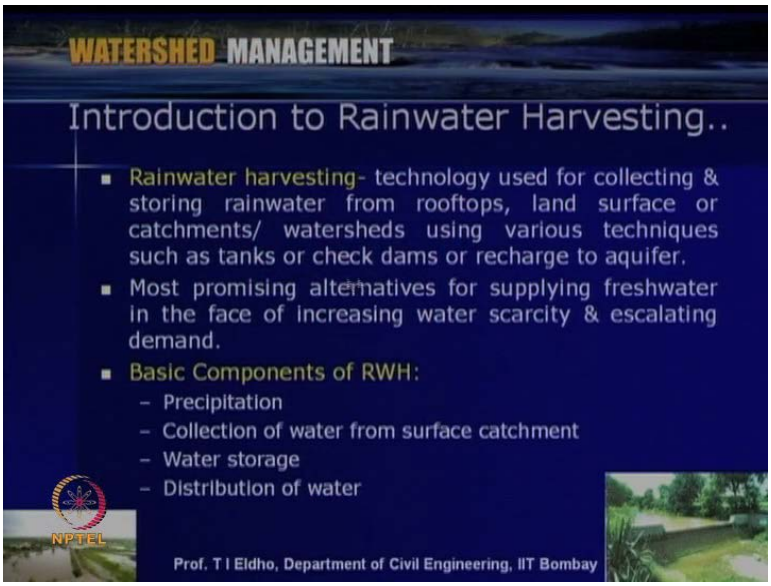

We can see that this say since we are collecting the water of at that particular location and trying to use their itself. So, that way rainwater harvesting is the most promising alternatives, for supplying fresh water in the face of increasing water scarcity and escalating demand. We can see that due to the growing population, due to industrialization and then we are expanding our agriculture. That way we needs lot of water and say we have already discussed earlier that more than say, if we consider India more than 60 percent of the countries say rain fed agriculture. If we can provide water for irrigation purpose, then we can increase the yield from the agriculture.

So, that way rainwater harvesting is one of the most important aspect say, as far as the rain any watershed management plans are concerned. And now let us see what the basic components of rainwater harvesting are? Of course, one of the important components the most important component is the rainfall or precipitation. It can be either say, as a rainfall or snow snowfall. And then second important component is collection of water from the surface catchment. We have already seen, the rainfall is converted to runoff. And this runoff is, that what we have to capture and then that is what the yield from that catchment is. The collection of the second important component in rainwater harvesting system is the collection from the surface catchment. It can be rooftop or a land surface or just like a watershed. And then the next component is water storage. We want to we have to store this collected water either in tanks or reservoirs or we can also recharge to the aquifer system.

Water storage, we are saying whenever rainfall is there we have got plenty of water. So, that some portion of that water we are trying to store for future use. That way the storage can be say just for like a domestic purpose, we can store in tanks and for agricultural purposes we can store in small small reservoirs like this or like this. And then say, most of the other times we can say even recharge to the aquifer system. So, that way we can utilize is available water say, during the lean period. And then the next component is distribution of water. The distribution once it is collected, we have to distribute the water. So, it can be through say small channel system, cannel system or though piping systems or it can be also pumping system from the ground water.

These are the important components of a rainwater harvesting. Now, let us discuss why we have to do this harvesting, so called rainwater harvesting. We have already discussed important aspects of rainwater harvesting.

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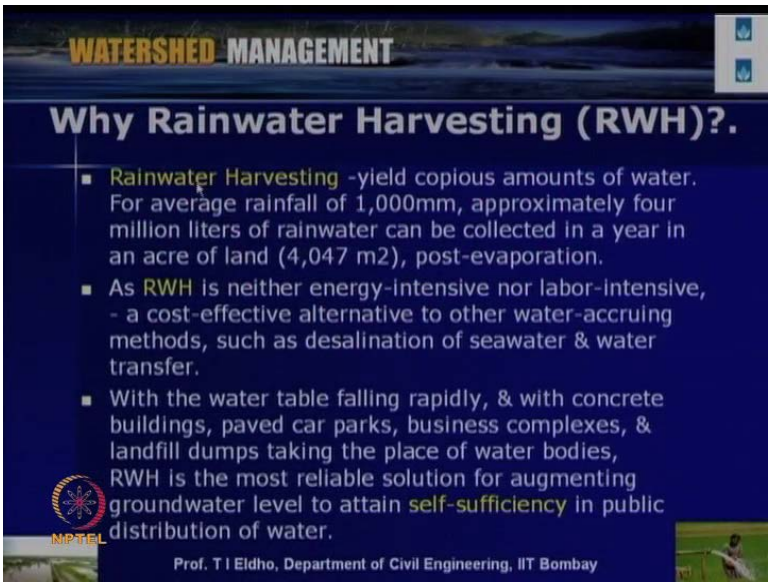

Now, why it is so important? Here in this slide, I have put say rainwater harvesting yield copious amounts of water say, for average rainfall of about 1000 millimeter. Approximately 4 million liters of rainwater can be collected in a year in an acre of land. An acre is almost approximately equal to 4047 square meter. Post evaporation is 1000 mm is the average rainfall then we can say, approximately say get 4 million liters of rainwater. That is the advantage. Say so much water we can collect, if depending upon the system which we utilize.

And then say, this rainwater harvesting is neither energy intensive nor labor intensive. A cost effective alternative to other water accruing methods, such as desalination of seawater and water transfer from one basin to another basin. This is there is no need of any energy or a say electric power to do this rainwater harvesting. And then one says system is made, it is not labor intensive only some annual maintenance is sufficient. So, that way rainwater harvesting is very attractive. And then another important aspect is say, as I mentioned say we can recharge this water to the aquifer system. With the water table falling rapidly and with concrete buildings, paved car parks, business complexes, and land freedoms taking the place of water bodies. Rainwater harvesting is the most reliable solution for augmenting the ground water level, to attain self sufficiency in public distribution of water.

Ground water as an important role, as far as the water plans of any country. This water says if you over draft then the groundwater table drastically will go down. So, that way we have to recharge say whenever rainfall is there, whenever sufficient surplus surface water is there. Especially, since now the non pervious area like, due to build up areas are increasing, especially in city and other areas. That way we can collect this water and then recharge to the aquifer system. then we can utilize back this water as ground water. So, that we can attain self sufficiency in the public distribution of water. That is the advantages. These are the reasons, why we have to go for rainwater harvesting.

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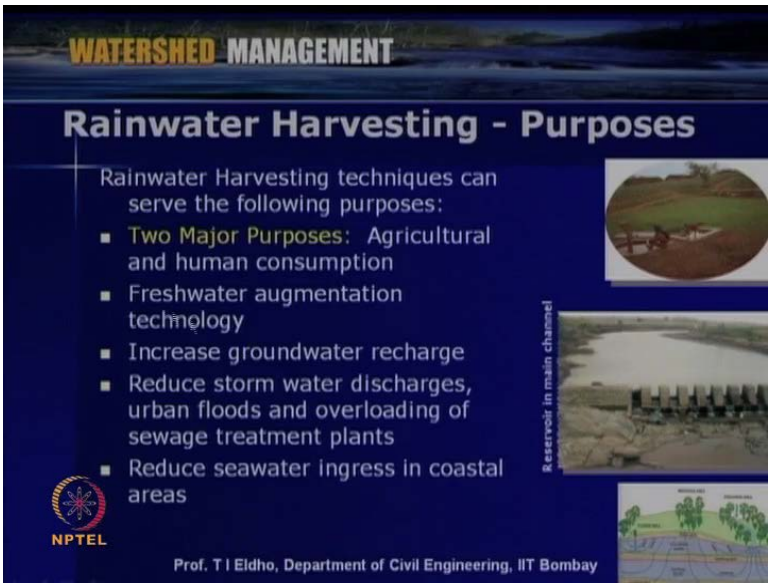

Now, let us see what the purposes of rainwater harvesting. The rainwater harvesting can serve the following purposes of mainly two major purposes. One is mainly for agricultural use we can say, directly harvest the water just like in a check dam like this and then we can use it for agricultural purposes. And then say like just like an in city, we can use the rooftop rainwater harvesting system, where water can be directly collected in tanks and then we can go for, we use it for human consumption. Then other purposes include, we can increase ground water recharge, as we already discussed and then we can reduce storm water discharges, urban floods and over loading of sewage treatment plans.

We can see that, if you can recharge more water to the aquifer system then the surface runoff will be reduced. So that way, we can reduce the urban flooding problems and then also in the storm water system the runoff will be reduced. So, storm water capacity can be reduced and if we can go for more recharge to the aquifer system. That way it is advantages. And then another advantage is that, we can reduce sea water ingress in coastal areas. In coastal areas, we can see that due to the over draught to the aquifer systems by huge pumping say, most of the time the sea water in drew to the coastal aquifer system.

If you can go for recharging say, rainwater using rainwater harvesting in these areas. Then it is a more water will be coming to the aquifer system. So, that to the sea water what is trying to increase to the aquifer system. That will be going back to the so, that we will be having more fresh water from the coastal aquifer system. That way, we can use this rainwater harvesting say methodology for to reduce this sea water ingress in coastal areas. Now, say we have seen the necessity of rainwater harvesting and then purposes also we have seen.

Now various methodologies we can adopt, as far as rainwater harvesting is concert. Some of the important methodologies are listed in this slide. Say the water harvesting, we can undertake through various ways. Some of the important methodologies are listed here, like a capturing runoff from rooftop. We can directly capture the rooftop rainwater and then either that can be stored in tanks on an appropriate way and then we can use it for future use or we can use that water for recharging purpose. That is generally called a roof water harvesting. In this we capture the runoff from the rooftops.

Then second one is we can capture runoff from local catchments. So, that we called it as land harvest. We can see that say, even in city areas lot of land will be there or say pavements and gardens etcetera. This water we can harvest in an appropriate way by collecting through the small small channels and then we can filtrate filter it through say, through some sumps and then we can use it for mainly for recharging purposes.

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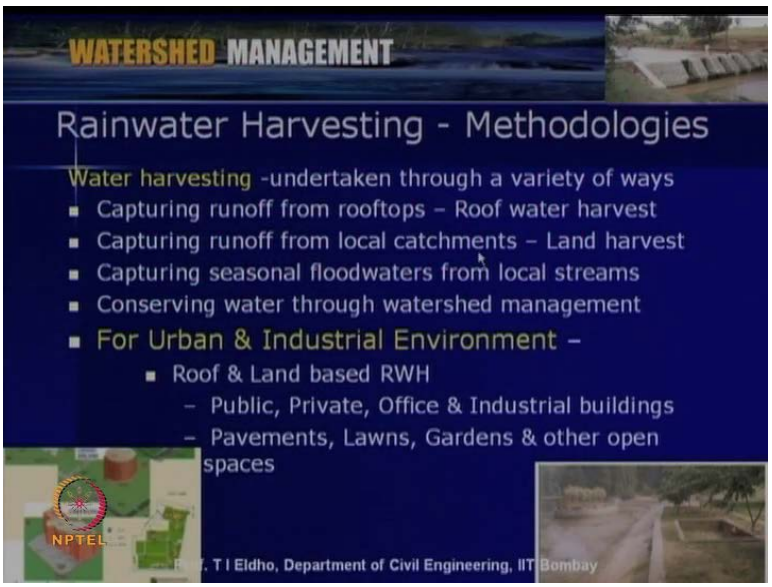

So, that is the second methodology. We can capture the runoff and then we can use for say, especially recharging that is so called a land harvesting. And then third one is we can capture seasonal floodwaters from local streams. Especially, whenever small small rivers are going. Whatever is coming through the river system the runoff, we can have a small small check dams like this and then we can have say storage. So, that can be directly used for agriculture purpose and also this same this can be utilized for recharging purpose. The nearby aquifer system will be also recharged in this way of rainwater harvesting. And then also we can go for a, we can conserve water through watershed management.

Watershed management various practices are there like land based or the stream wise. various practices we can follow in watershed management rainwater harvesting. That is the fourth methodology. And says, especially for urban and industrial environment generally, we go for say roof and land based rainwater harvesting system. We can see that here the roof, water what is coming we can directly collect it and the electric store or

used for recharging. This can be done in public, private, office and industrial buildings. And then land based this say, just like a lot of land is there the urban area. So, like pavements lawns gardens and other open spaces.

This water we can collect it and either we can put in a small pond and then utilize or we can allow this water to recharge to the aquifer system. So that, that way the land available even in industrial or an urban area we can directly utilize. These are some of the important methodologies of rainwater harvesting.

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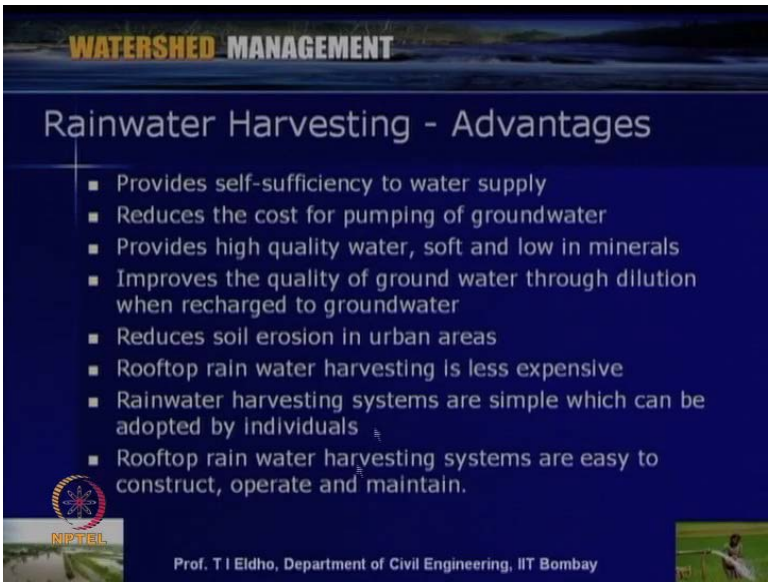

Now within this prospective, let us look what the important advantages of rainwater harvesting. There are number of advantages of rainwater harvesting say, as far as disadvantages or limitations. There are no assets, there are no limitations since, it is always beneficiary. some of the important advantages are listed here in this slide rainwater harvesting provide, self sufficiency to water supply as we already discussed, then reduces the cost of pumping of groundwater. When we are recharging the water level rises. That way we can reduce the cost of pumping, then provides high quality water soft and low in minerals. Especially, for industries where hard water is an issue, then we can say rain water is soft water and then low in minerals directly we can utilize since, the quality of the rainwater is very high.

Then it improves the quality of ground water through dilution when recharged to groundwater. Say especially, in some areas wherever the groundwater pollution is there, if you can recharge a good amount of rainwater then dilution will takes place and then that the groundwater itself will be getting the quality will be getting better. Then the rainwater harvesting helps to reduce soil erosion in urban areas. So, various structures which we constructed for rainwater harvesting that will reduce the soil erosion. Then rooftop rainwater harvesting is less expensive. If you do a cost analysis, we can see that this is one of the less expensive ways of say, water conservation and utilization. And then rainwater harvesting systems are simple, which can be adopted by individuals there is no complicated technology the technology is very simple, we can easily adopt it.

Then rooftop rainwater harvesting systems are easy to construct operate and maintain. Simple design and operation maintenance are very simple, as far as rainwater harvesting is concerned. And then some other important advantages say, in hilly terrains rainwater harvesting is preferred.

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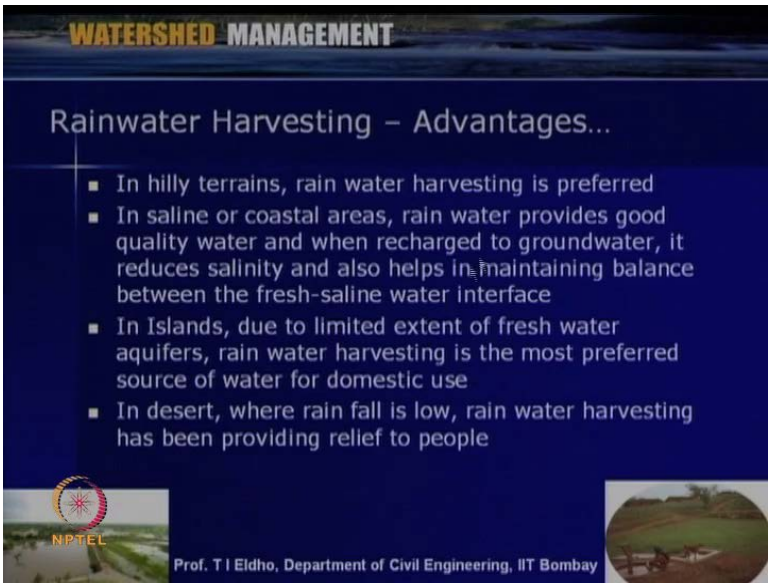

So, there we can especially this rope is very high then we can see that most of the water will be drain out. There if we can store or we can use for rainwater for recharging in hilly terrains. Then in saline or coastal areas rainwater provides good quality of water. And when recharge to ground water, it reduces salinity and also helps in maintaining balance between the fresh saline, water balance, water interface. This we have already seen, we

can reduce the salinity ingress to the coastal aquifer systems. And then in islands, due to limited extent of fresh water aquifers, rainwater harvesting is the most preferred source of water for domestic use.

Especially in island say, wherever say surrounding say all the all the four sides of surrounded by sea. Then you can see that even the aquifers on the coastal sides may be affected by salinity saline water. There if you can directly harvest and we can directly utilize the rainwater. Then in desert region, where rainfall is much less, rainwater harvesting is the only source of say water. Many areas this rainwater harvesting has been implemented and has been found to be huge success, as far as arid and semi arid regions are concerned. We can that this way we can see that only advantages are there, as far as rainwater harvesting is concerned. Even though at the beginning, there may be say we have to invest some more money, but within one or two years whatever invested money we will get back. As this is one of the say, less expensive way of water conservation and water yields.

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Now, as far as rain water harvesting is concerned different techniques, different technologies are available. Some of the important techniques are listed in these slides. This depends upon; the area depends upon say what kind of topography, etcetera. Accordingly, we can say the technology can be classified into mainly for three types of areas. First type of say type is form rainwater harvesting structures. Depending upon say,

we have to see depending upon the topography. Topography means what say, what is the slope of the land? What kind of soil? And then also it depends upon the rainfall and then what kind of structures we can implements like economic status. and then built up areas are say, we can go for tanks like a in traditional temple tanks, then rooftop harvesting, then wells and radiators wells, parking lots storage, recreational park ponds.

Various schemes we can develop for built up areas. Then open areas like in a watershed, we can go for percolation ponds, where water will be say stored for some days. That will be source of our recharge, as well as utilization for domestic power, agricultural purposes. Then we can construct in filtration galleries, then community wells, farm ponds, ducts, amicus across the stream, etcetera. There are various techniques are available, as far as rainwater harvesting is concerned. Depending upon the area, depending upon the requirements, depending upon the money which we can invest we can choose particular technique for that particular location. And it depends upon, what is the use of the rainwater what is harvested say, like whether domestic consumption or whether it is for agriculture purpose or gardening.

Accordingly, we need good quality water or say the quality can be say slightly less. Say for example, if it is for agricultural or gardening purpose. So, that way we can chose appropriate technology for rain water harvesting and then that we can implement. Now, let us go back to say, how much water we can harvest. say as a say for example, particular area is concerned or a particular watershed is concerned. Rainwater harvesting potential let us look into.

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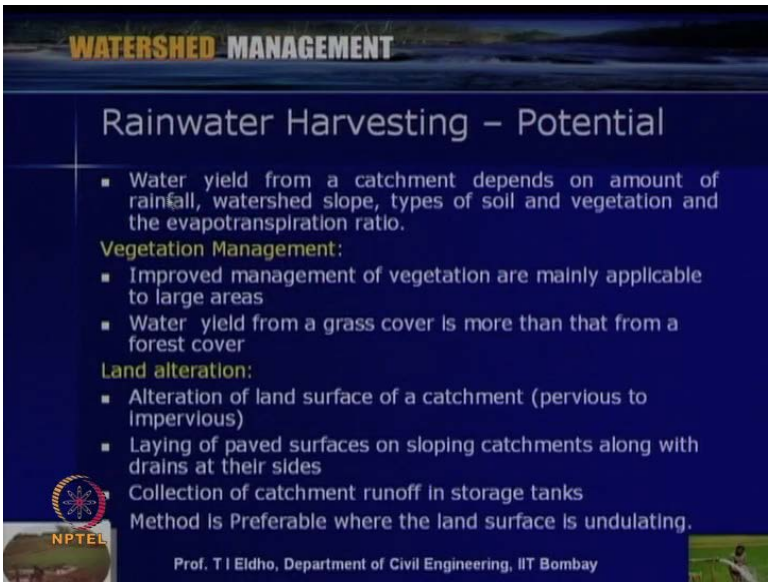

The water yields from catchments. The rainwater harvesting a catchment depends on the amount of rainfall, watershed slope, types of soil and vegetation and evapotranspiration ratio. Accordingly, the rainwater potential varies depending upon the area, like a how much is the rainfall and then how much is the intensity? What is the duration of rainfall? Then what the slope of the lands is? Then what kind of soil? So, infiltration rate depends upon the soil type and then vegetation of the area. The since evapotranspiration depends upon that.

Then accordingly, depending upon say if the vegetative cover says, like vegetation management we can do so, in such a way that we can go for improved management of vegetation. Mainly applicable to large areas and water yield from a grass cover is more than that from a forest cover. Depending upon the area, we can do a vegetative management and then we can also go for land alteration. Depending upon what kind of, whether it is built up land or it is open space; accordingly the rainwater harvesting potential varies.

Alteration of land surface of a catchment say, from pervious to impervious then there will be lot of changes will be there. There are no field is increased, when it will goes to pervious to impervious. And then laying of paved surface on slopping catchment along with a drains at their sides.

Accordingly say for example, in nowadays porous pavement we can make, and then some portion of the water will be recharge. Like that we can do land alternation, then collection of catchment runoff in storage tanks. Depending upon the area, we can do. Then they say, the method is preferable where the land surface is undulating. Depending upon the catchment, depending upon the rainfall condition, depending upon the vegetation the rainfall rainwater harvesting potential varies from one location to another location. Accordingly, we have to do a study and then identify, what will be the potential of rainwater harvesting for the particular area is concerned.

So, now let us look into the hydrological aspects of rain water harvesting. Mainly the important component is the precipitation or snowfall or says the runoff, what is coming from the rainfall or snowmelt.

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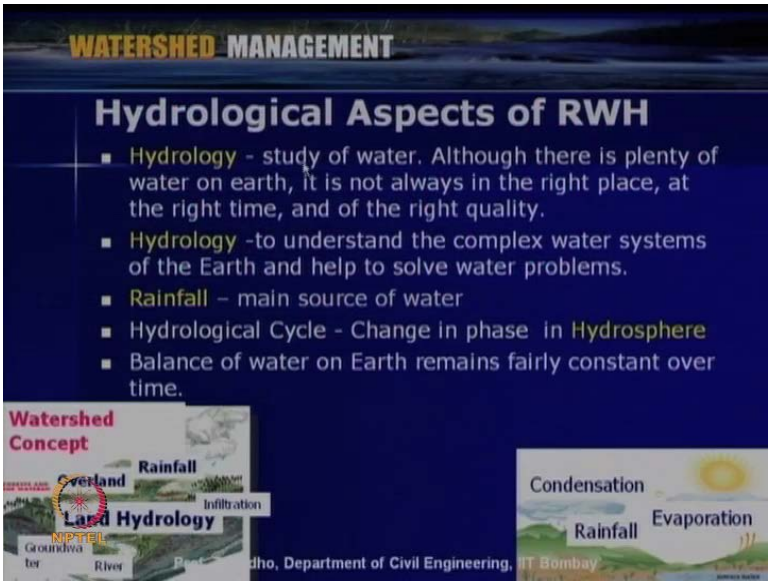

So, accordingly the hydrological aspects of a very important, as far as rainwater harvesting are concerned. As we already discussed earlier, the hydrology is the study of water. Although there is plenty of water on earth, it is not always in the right place at the right time and of the right quality. So, this we have already discussed. Through hydrological studies we are trying to understand, the complex water systems of the earth and we are trying to solve various water related problems. Just like say, how much water can be harvested, how it can be harvested, and where it can be harvested so like that.

As far as hydrology is concerned the say, as we discussed rainfall is the main source of water, which we are trying to utilize in different ways. The hydrological cycle as we discussed earlier also, that is one of the important aspect what is happening with respect to rainfall to runoff. And then this passing of the runoff to the sea and then evapotranspiration and condensation like that. The in hydrological cycle same it water is say, change in one phase to another phase in the hydrosphere. So, the balance of water on earth remains fairly constant over the time. Even though the population is increasing, the water demand is increasing, the agriculture is increasing, but the water availability says, it is almost say remains constant over time. That way we have to use judiciously in such a way, that with respect to the available water we have to manage our demand.

That way the hydrological study is very important in for rainwater harvesting for a particular area. As I mentioned in hydrological studies, we have to see how much is the runoff potential for a particular area. Rainfall to runoff, we have already seen various processes will be there with respect to rainfall to runoff.

Various processes such as evaporation, transpiration, then infiltration, interception, then percolation, in like that various processes will be there. These we have to consider, when we go for rainwater harvesting.

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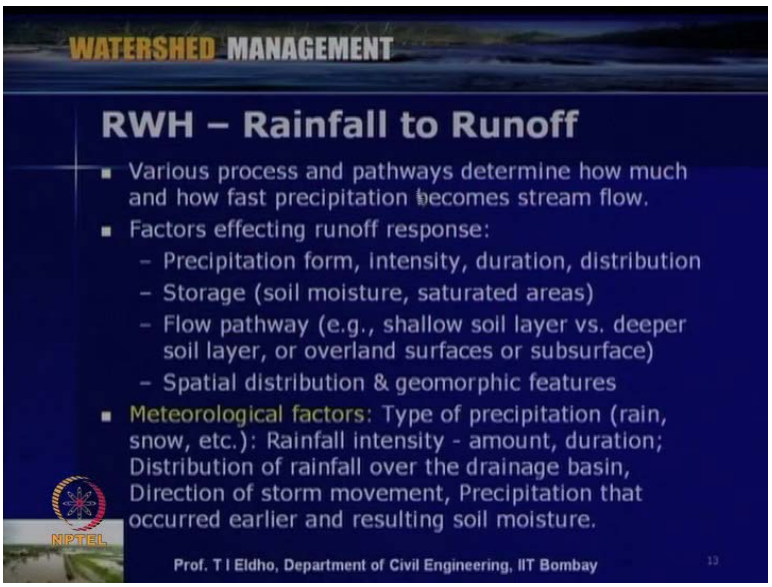

The various processes and pathways determine, how much and how fast the precipitation becomes the stream flow or converted to runoff. some of the important factors as we discussed or precipitation form, the intensity of precipitation, duration of the precipitation, and the distribution of that precipitation within an area or within a watershed. And then also it will depends upon, how much is the water storage especially in the soil. Like soil moisture and then how much say area is saturated. Once the soil is saturated, then only the runoff starts. And then the flow path way like a say for example, the shallow soil layer versus deeper soil layer or over land surfaces or subsurface. So, like that the flow path is very important say, when the rainfall is converted to runoff. And then this spatial distribution and geomorphic features.

What is the geology of the area? What is the geomorphic pattern of the area? Depending upon this the rainfall to runoff conversation takes place and then, we will be say we can identify how much is the possible storage. Then also, we can see that the meteorological factors very important. The precipitation since, we are most of the time we are depending upon the precipitation as the source of water, as far as rainwater harvesting is concerned.

The type of precipitation like a rain or snow, then rainfall intensity say, how intense whether it is intensity is very high or low intensity. So, that we can identify how much is the amount, and then duration of the rainfall, and then distribution of rainfall over the drainage basin, then direction of storm movement, precipitation that occurred earlier and resulting soil moisture. This depends upon the runoff conversion rainfall to runoff depends upon the infiltration. If the soil moisture is already there with respect to previous rainfall, then we can see that the runoff generation will be faster.

That way these are some of the important issues which we have to discuss, as far as the rainfall to runoff conversion is concerned. Now within this perspective say, let us discuss as far as rainwater harvesting is concerned, how much water can be harvested? So, that let us discuss say for a particular area.

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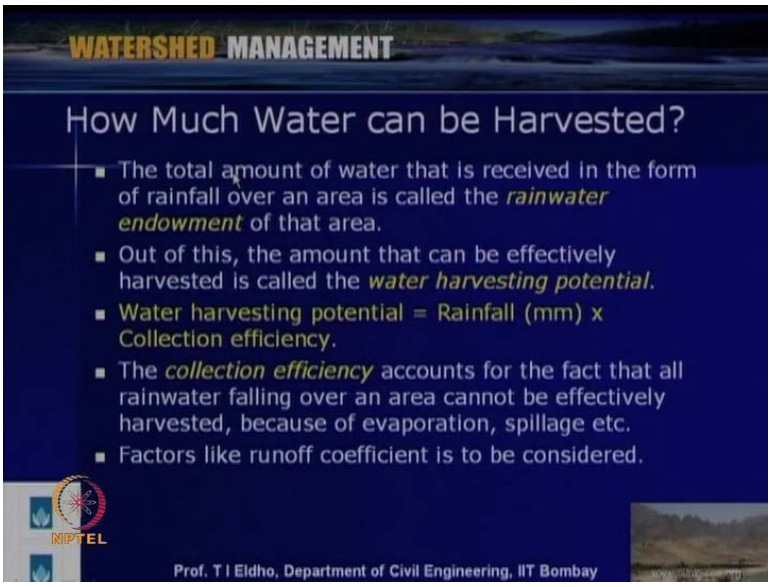

When the rainfall is converted to runoff, the total amount of water that is received in the form of rainfall over an area is called the rainwater endowment of that area. Rainwater endowment means, it is based upon the total amount of rainfall say taking place for that particular area. And out of this the rainfall the amount that can be effectively harvested is called the water harvesting potential of that particular area. When we design rainwater harvesting system say, first we have to see what is the rainwater endowment. And then we have to identify, what is the rainwater harvesting potential, as far as the area is concerned.

The rainwater harvesting potential, we can put us that that is equal to rainfall into the collection efficiency. We can see that number of loses will be there like evaporation will be there. Then the infiltration will be there and then the collection related problem will be there. According to (( )) the water harvesting potential depends upon, the rainfall and the collection efficiency that is equal to rainfall multiplied by the collection efficiency. The collection efficiency accounts for the fact, that all rainwater falling over an area cannot be effectively harvested, because of evaporation, spillage, etcetera.

That way we have to account a factor called runoff coefficient. Generally in most of the design of rainwater harvesting, we take a coefficient called runoff coefficient and then use this coefficient, to identify how much will be the water harvesting potential for that particular area.

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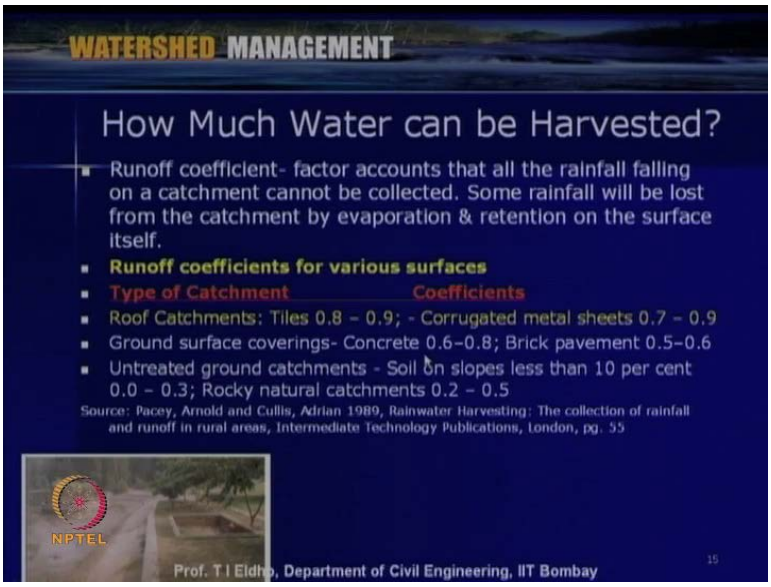

This runoff coefficient, it is a factor that accounts that all the rainfall falling on a catchment cannot be collected or harvested. So, some rainfall will be lowest from the catchment by evaporation, infiltration, retention like that save on the surface itself. That way we have to identify this runoff coefficient for the given location or given area. Some of the runoff coefficient for various surfaces few of the surfaces I have listed here; this is based upon this reference.

The type of catchment the runoff coefficient says for example, roof catchment. If it is tiles, it may vary from 0.8 to 0.9. Then corrugated metal sheet, it can vary from 0.7 to 0.9. And then ground surface coverings like if it is concrete, it can vary from 0.6 to 0.8. If it is brick pavement, it can vary from 0.5 to 0.6 and then if it is untreated ground catchment soil on slopes less than 10 percent, it will vary from 0 to 30 percent or 0 to 0.3. Then rocky natural catchment, it can vary from 0.2 to 0.5. Like that say, depending upon the area where you are going for rainwater harvesting, we have to identify what will be the runoff coefficient. So, the runoff coefficient depends upon the nature of the surface.

Whether it is a concrete, whether it is soil or whether it is a pavement. Accordingly the runoff coefficient will vary. These runoff coefficient standard values are available based upon number of field experiments or laboratory experiments. Based upon your area

where you are going for rainwater harvesting, we can choose particular runoff coefficient.

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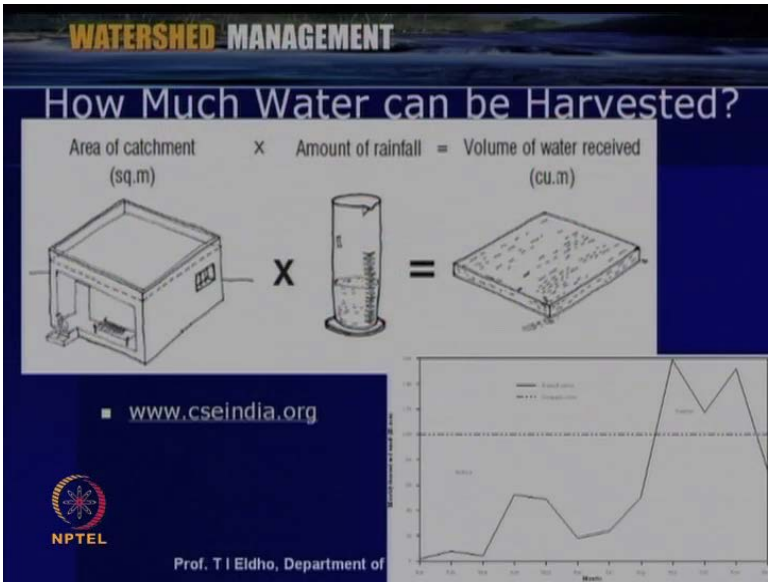

Now, the question comes how much water can be harvested? So, this figure is taken from cseindia website. This is the area of the catchment say for example, if it is roof this much is the area of a catchment, and then multiplied by amount of rainfall. If we can identify, how much is the amount of rainfall. Whether it is 100 mm or1000 mm so, that way will give the volume of water received. That is the total volume. Then of course, we have to multiplied by a coefficient called runoff coefficient, depending upon the collection efficiency and the area

Now, if you plot say for example, in this figure this say this is a months and this is the variation. So, here you can see that depending upon the location the rainfall varies monthly variation takes place. If this is the monthly average, monthly variation for that particular area and if this is our demand of say, for the water is concerned then you can see that say, this is the lean period and here we have so much of water due to the rainfall.

Depending upon that depending upon the rainfall pattern and depending upon the demand of that particular location, we can ah design a particular rainwater harvesting system for the desired requirements for the particular area is concerned.

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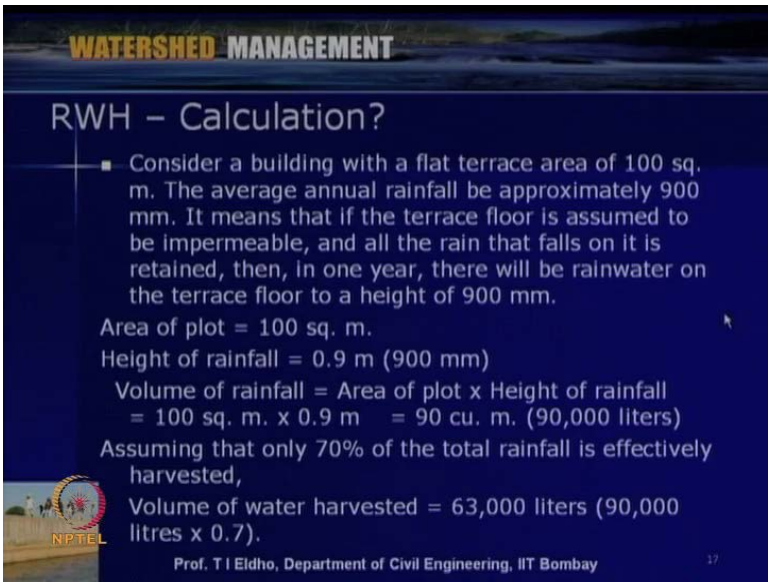

Accordingly, we can calculate how much is the rainwater harvesting. The calculation is based upon we can say for example, if you consider a building with a flat terrace area of 100 square meter, the average annual rainfall the approximately 900 mm. It means that if the terrace floor is assumed to be impermeable and all the rain that falls on it is retained. Then in one year there will be rainwater on the terrace floor to a height of 900 millimeter. Area of the flat is say the 100 square meter, height of rainfall is 0.9 meter. Volume of rainfall area plot multiplied by the height of rainfall, it will be about say 90 cubic meters. If say for the due to various reasons, like a collection efficiency and then various losses. Then if 70 percent of the total rainfall is effectively harvested, then we can see that how much we can harvest for this particular 100 square meter area, will be 63000 liters while considering the collection efficiency of 0.7.

Let that we can calculate, how much is the rainfall say rainwater harvest harvesting can be done depending upon the type of the location. Say whether it is rooftop or it is say open space and then how much is the rainfall, and then how much is the collection efficiency.

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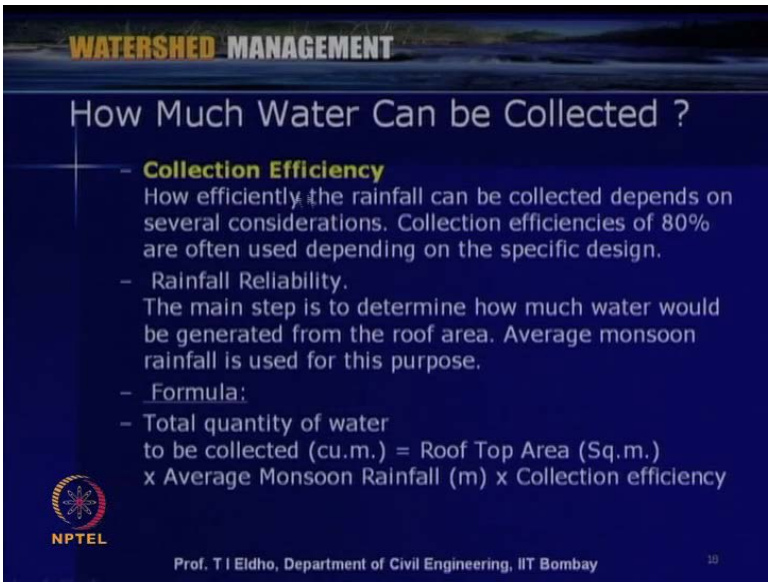

This collection efficiency is concerned say, how efficiently the rainwater can be collected as we discussed already to depend upon several considerations. So, say maximum of say, we can consider 80 percent collection efficiency depending upon various aspects, for the specific design is concerned. and then the other issues rainfall reliability. The main step is to determine, how much water would be generated from the roof area. Average monsoon rainfall is used for this purpose. and then as we have already seen in the previous slide. The variation according monthly variation we can consider and then we can plan. For this many months directly we can utilize from the rainfall and this much can be collected for the coming months.

So, the simple formula is total quantity of water to be collected is equal to rooftop area multiplied by the average rainfall into collection efficiency, as we discussed earlier. So now, let us come back to the scenario in India.

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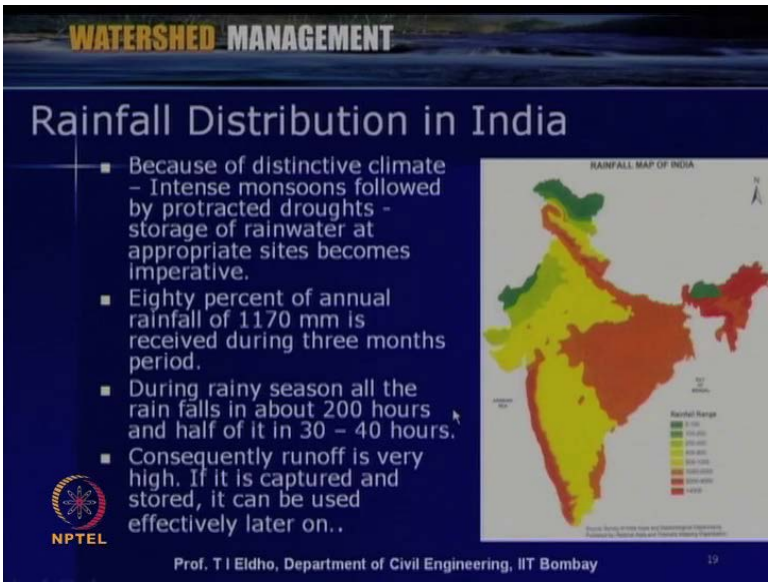

As we have already discussed in India, because of distinctive climate due to the monsoon rainfall pattern. The storage of rainwater at appropriate sites becomes very important. We have some area of say for example in location like Kerala, eight months rainfall is there, but in many other locations say, two months or two to four months rainfall. Depending upon the area and depending upon the rainfall pattern, we have to go for the rainwater harvesting system.

So, 80 percent of annual rainfall of say, for India is concerned. The average annual rainfall is we can consider as 1170 millimeter. And out of this 80 percent we will be received in three months of time starting from July august September. And during rainfall season, all the rainfall is taking place in about 200 hours and half of it will be happening in 30 to 40 hours. This is the main issue, even go for rainwater harvesting we need to specifically design particular rainwater harvesting depending upon the location.

Consequently run off is very high in most of the locations and if it is captured and stored, it can be used effectively later on. To while going for a rainwater harvesting design, we have to identify what is the rainfall pattern. it is distributed say for four months or eight months or what is the intensity and how many days of rainfall and how many hours of rainfall accordingly, we can design.

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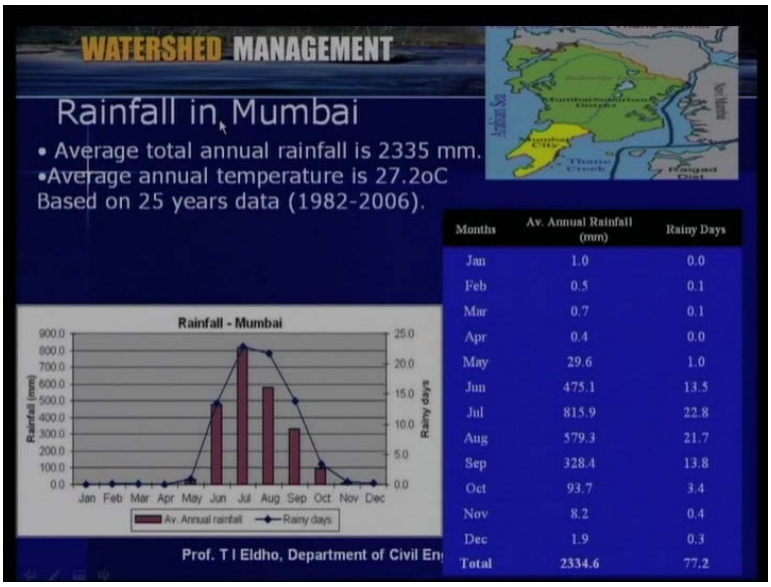

So now say for example, if Mumbai is concerned say, rainfall in Mumbai average total annual rainfall based upon date of 25 years is about 2335 millimeter. For the Mumbai area and the rainfall is a varying like this say, the main rainfall season is June, July, august, September. And number of rainfall days say, it varies depend upon the month also. So, when we go for a design, rainwater harvesting design. We have to get such a plots say average annual rainfall pattern, monthly base pattern and then how much is the average annual rainfall and the number of rainy days.

These kinds of data will be very helpful to design appropriate rainwater harvesting system for that particular location. Rainwater harvesting system can be either rooftop based system or the land based system or the watershed based system. We have to see the hydrological aspects as we discussed say, the rainfall variation monthly variation and the rainfall intensity variation, then number of days or number of hours of rainfall. All these data, we have to collect appropriately and then we have to utilize this data to identify, how much is the rainfall potential. And then we have to identify, what will be the runoff coefficient. So, that we can go for a better rainwater harvesting design system.

And now as we discussed early, the one of the important aspect of rainwater harvesting is groundwater recharge. Since, say we cannot store so much of water on this surface or reservoirs or tanks for immediate use. The best solution will be, rainwater harvesting will be to store the water underground or so called in aquifer system. For that say, we have to study the details of the geological pattern of that particular area. When we go for recharging especially, artificial recharges design. Of course natural recharge takes place, but to increase that recharge, we can go for artificial recharge.

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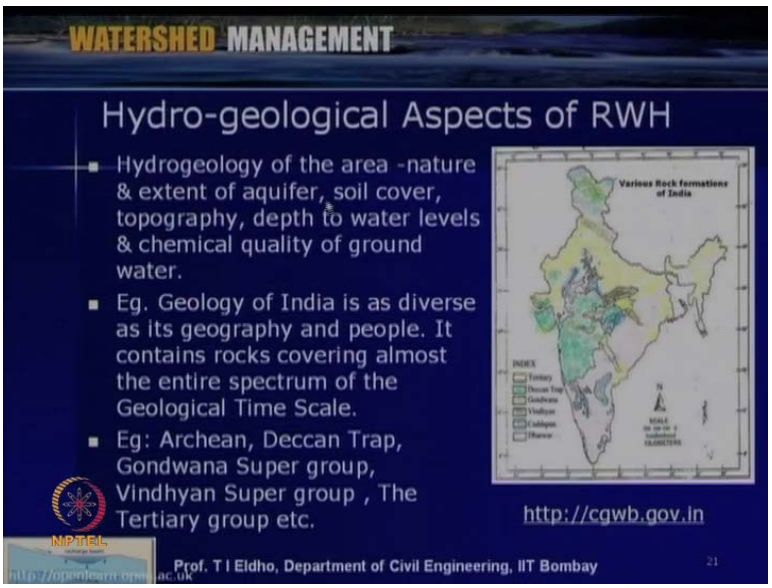

The hydrogeology of the area is very important. These depends upon the nature and the extent of the aquifer, soil cover, topography, depth to water levels and then of course quality of the groundwater. Say this figure shows the various rock formation of India. Say for example, the geology of India is as diverse as its geography and people. So, the people culture and the nature varies from one location to another location are very similar way the geology of India is also varying. It contents rocks covering almost the entire spectrum of the geological time scale like an archean, Deccan trap, gondwana super group, vindhyan super group, etcetera.

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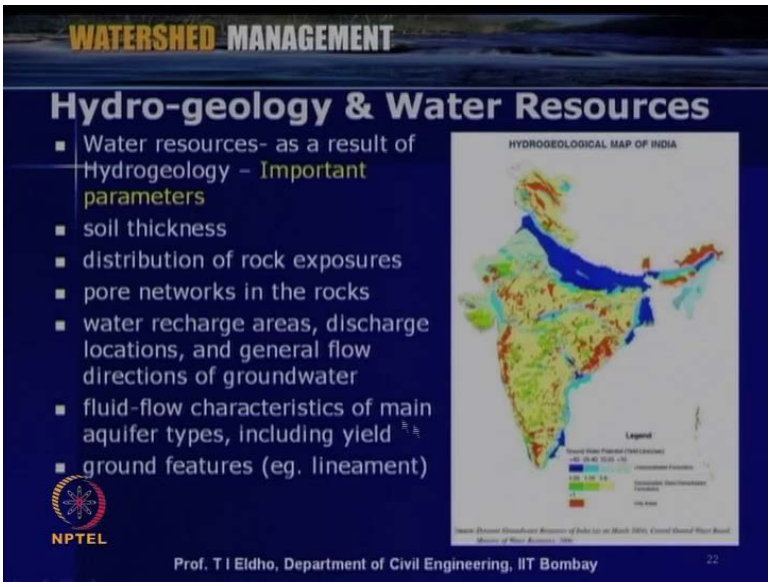

This graph is taken from centre groundwater board website. And then they say, as I mentioned at the main source of groundwater is say, this infiltration taking place during the rainfall or the recharge to the aquifer system. Water resource as a result of hydrogeology some of the important parameters, which we have to consider in the process of this kinds of the infiltration or percolation to the aquifer system depends upon the soil thickness. Distribution of rock exposures, pore networks in the rocks, then water recharge areas, discharge locations, general flow direction of ground water, then fluid flow characteristics of main aquifer types, including the yield and then ground features like a lineament.

All these we have to study in details. Before going for a rainwater harvesting design, especially in terms of the groundwater recharge or aquifer recharge, we have to see the geological pattern of that location. Especially watershed basis, we have to see the geological pattern, the soil pattern, the soil thickness. All these we have to see while designing appropriate rainwater harvesting structures especially, for groundwater recharge. Say for example, this is the hydro-geological map of India. We can see that say, depending upon their location the hydrogeology change. So accordingly, the rainwater harvesting for recharge also the methodology will vary and then the recharging rate also will vary.

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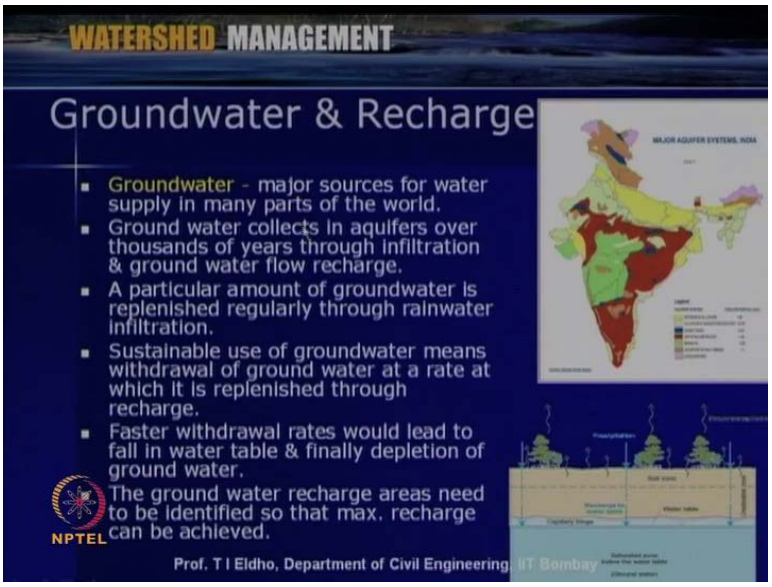

Now the as we have already discussed, groundwater is the major source of water supply in many parts of the world. And groundwater collects in aquifers over thousands of years through infiltration. And groundwater flow recharge, a particular amount of groundwater is replenished regularly through rainwater infiltration. Natural infiltration takes place, but through artificial way we can increase this recharging. Sustainable use of groundwater means, withdrawal of groundwater at a rate at which it is replenished through recharge.

If we are using particular amount of say, groundwater then that amount should be replenished through the year due to the rainfall taking place. So, that sustainability will be there. Otherwise what happens, if we are keeping on pumping and if sufficient recharge is not taking place to the aquifer system, the groundwater level will drastically go down. So, that will create say other problems. We have to see a sustainable recharging pattern for the particular area. Faster withdrawal rates would lead to fall in water table and finally depletion of the groundwater. the groundwater recharge areas need to be identified. So, particular area depending upon the soil nature which that you cover etcetera.

We have to increase the recharge possibility. So, we have to identify the area and then we have to design appropriate structures, as far as the rainwater harvesting is concerned or recharge is concerned.

This figure shows the major aquifer system of India. Depending upon that, we can plan the rain the recharge structures especially, when we go for artificial recharge.

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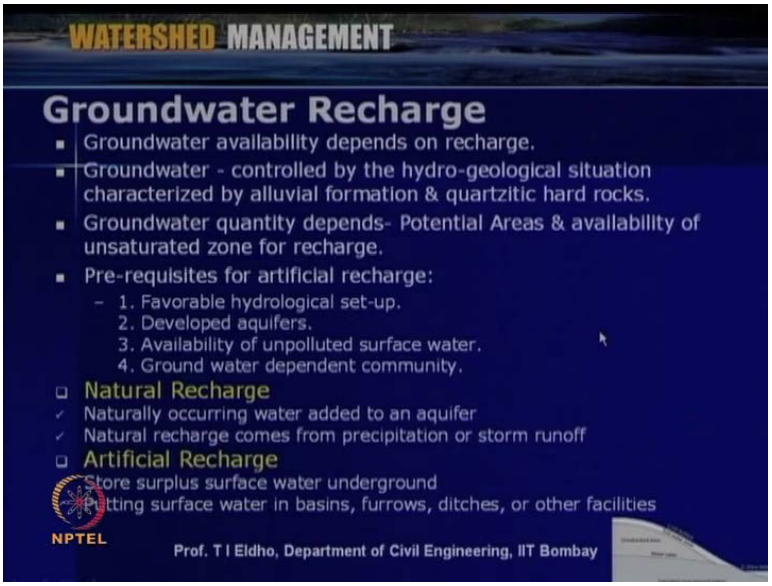

The groundwater recharge is concerned, groundwater availability depends upon the recharge as we already discussed. So, the groundwater is controlled by the hydro-geological situations characterized by the alluvial formation and the type of rock. The groundwater quantity depends upon the potential areas and availability of unsaturated zone for recharge. When we before we go for artificial recharge, as I mentioned we have to study the details of the hydro-geological pattern and then how much aquifer the developed aquifer system. Then availability of unpolluted surface water, then groundwater dependent community whether, how much usage is taking place for the particular area.

As I mentioned the recharge can be natural recharge or artificial recharge. Natural recharge means naturally occurring water added to an aquifer depending upon the rainfall pattern. Then natural recharge comes from precipitation or storm runoff. Then artificial recharge means, we are providing particular structures to increase the recharge rate. Thus we store surplus surface water underground and that is allowed recharging putting surface water in basins, furrows ditches or other facilities.

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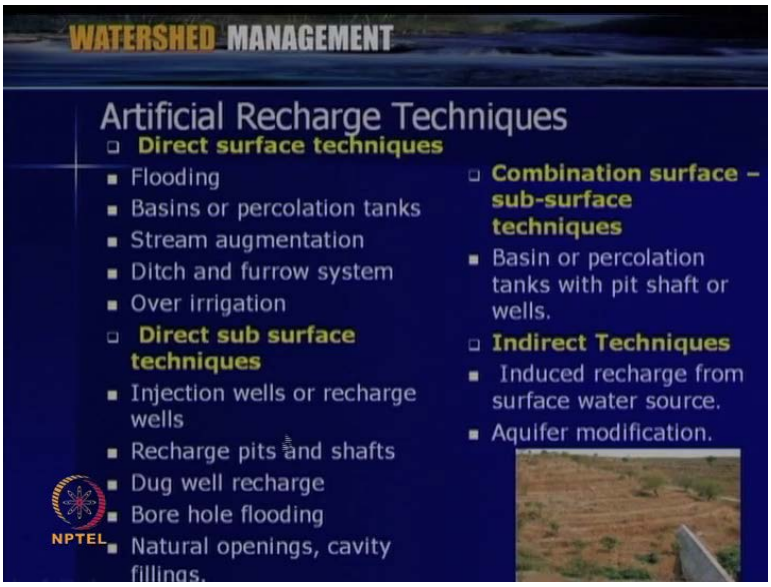

Artificial recharge, nowadays says many of the government agencies are giving lot of importance for artificial recharge techniques. Depending upon the area depending upon the need various techniques are available, as far as artificial recharge is concerned. Like a direct surface techniques, like a simple flooding basins or percolation tanks, then stream augmentation, ditch and furrow system, and over irrigation of the area. These are some of the direct surface techniques.

Then we can go for direct subsurface techniques like injection wells or recharge wells, recharge pits and shafts, dug well recharge, bore hole flooding, natural openings, cavity filling, and etcetera. and then also we can have combined surface and subsurface techniques like basin or percolation tanks with pit shaft or wells. Then we can go for indirect techniques like induce recharge from surface water source, aquifer modification, and etcetera.

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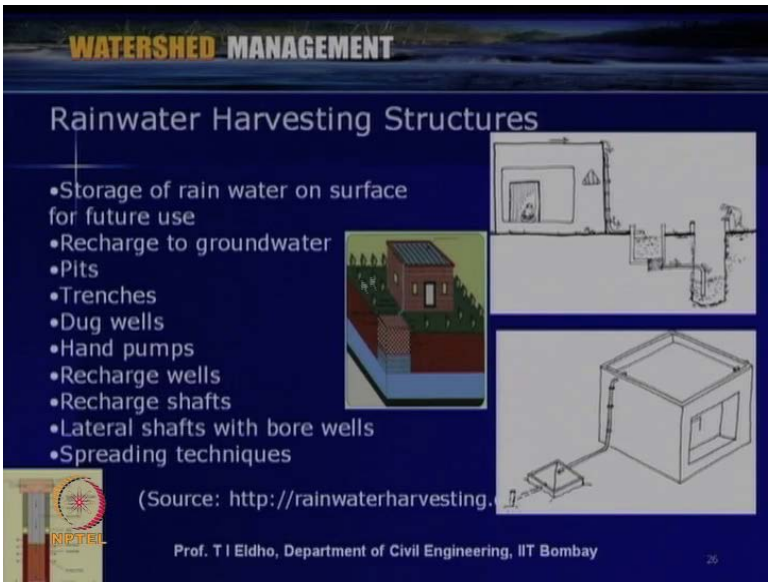

So, these are some of the important artificial recharge techniques we can adopt depending upon the area. As far as rainwater harvesting structures especially, for recharge is concerned depending upon the area, depending upon the location. We can have various structures like storage of rainwater on surface for future use. That is the rainwater harvesting through recharge. The recharge to groundwater says, through pits we can have pits like this or trenches like this. Trenches dug wells, then through hand pumps wells, recharge wells, recharge shafts. So, various techniques we can adopt then lateral shafts with bore wells, spreading techniques. So, this website give gives various techniques of rainwater harvesting structure for especially for artificial recharge.

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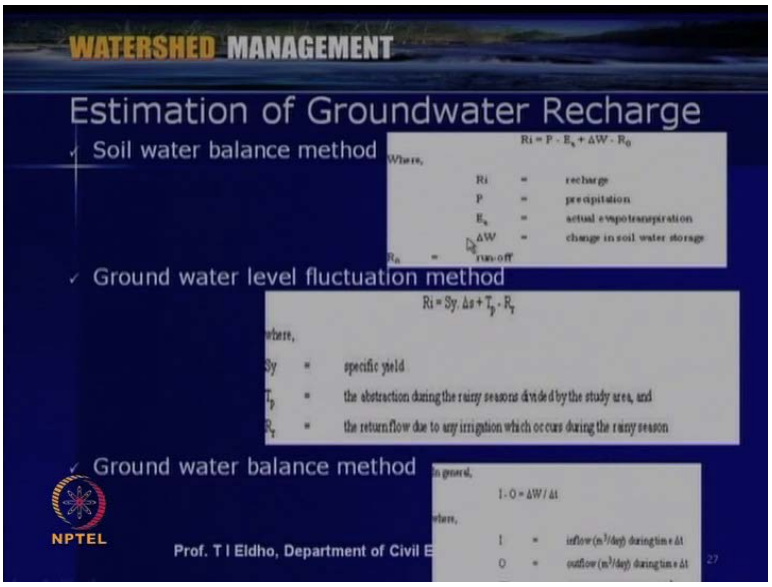

So, while doing this artificial recharge, most of the time we have to also identify how much ground water recharge is taking place. Simple techniques are available to do this to quantify, how much recharge is taking place. Most commonly used techniques are soil water balance method. In this the recharge is equal to the precipitation minus evapotranspiration plus the change in soil storage minus the runoff that is soil water balance method. Then we can use simple ground water level fluctuation method. there the whatever we can harvest is equal to S Y into delta S plus T P minus R T where, S Y is the specific yield and then delta is this raise of the water table, then T P is the abstraction during the rainy season and R T is the return flow due to any irrigation, which occurs during the rainy season.

Then we can go for ground water balancing method. That is a simple equation like inflow minus outflow is equal to change in storage. So, this equation gives ground water balancing method. Depending upon the requirement, we can go for particular simple technique and then calculate this much is the recharge taking place for that particular area.

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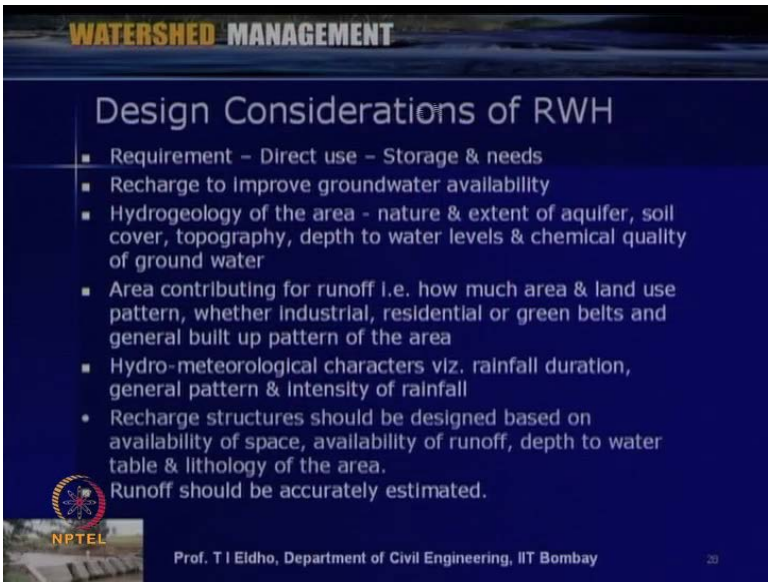

Now some of the important design considerations of rainwater harvesting are say, what kind of requirement whether we are going for direct use just like a storage or we are going for recharge to improve the ground water availability. And then we have to identify what will be hydrogeology of the area, then like a nature and extent of aquifer, topography, and etcetera. Then the area contributing for runoff, how much is the area of what is contributing for runoff.

Then hydro-meteorological characteristics like rainfall duration, rainfall intensity, etcetera. Then recharge structure should be design based upon the availability of space, availability of runoff, depth to water, and table lithology of the area. We can calculate how much is the runoff and then we can estimate say, we can designed the rainwater harvesting technique appropriately.

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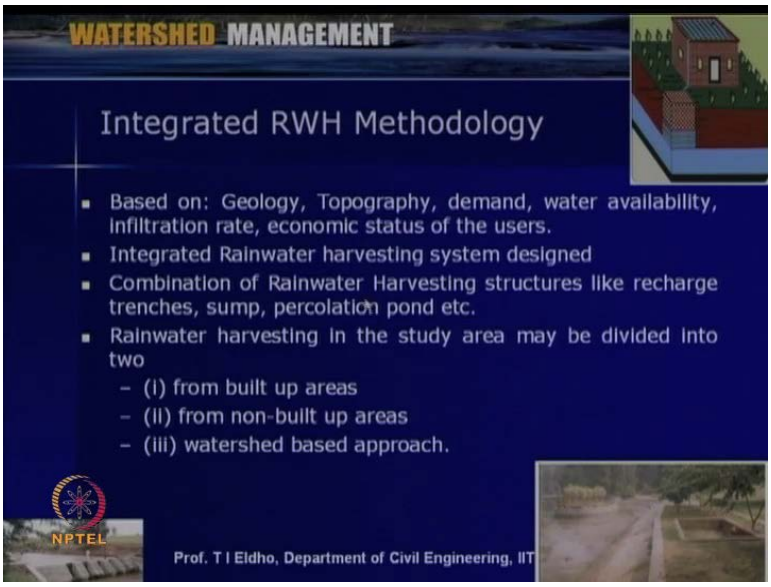

So, now one particular watershed or particular area is concerned, we can go for an integrated rainwater harvesting methodology. This can be based on the geology, topography, demand, water availability, infiltration rate, economics status of the users.

Integrated rainwater harvesting system we can design. So, this is a combination of rainwater harvesting structures like recharge trenches, sump, percolation pond. This can be including the roof top rainwater harvesting, then the land based rainwater harvesting, and then also watershed based approach.

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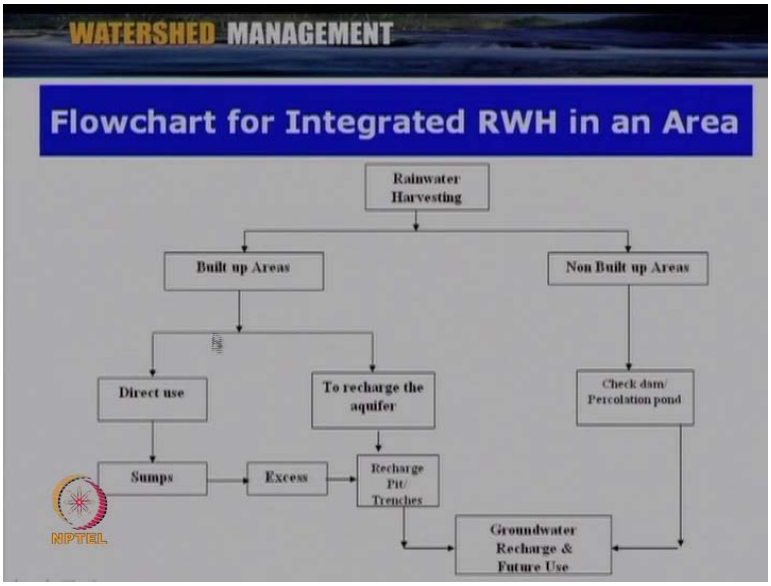

So, that way here I have a put a flowchart for integrated rainwater harvesting in an area. This is the rainwater harvesting, which is which we have wanted to identify. We can identify, how much the built up area and none is built areas. So, built up area we can identify how much water is we want to store for direct use and how much you want to recharge. From the direct use after storage, how much will be excess taking place that we can put for recharging. And then finally, that will be contributing to the ground water recharge.

None built up area; we can store some water in a small reservoirs or percolation pond and remaining water that can go as groundwater recharge. we can design an integrated rainwater harvesting for that particular watershed or particular area depending upon the need depending upon the various local conditions.

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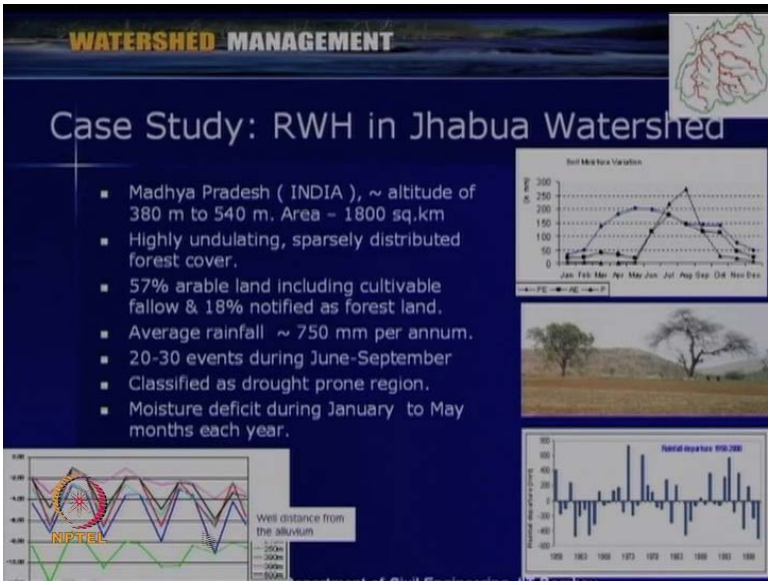

Before closing at today's lecture, let us go through briefly go through a case study. The case study is the rainwater harvesting done in jhabua watershed. This jhabua watershed is in Madhya Pradesh and area is about 1800 square kilometer and altitude varies from 380 to 540 meter

And this is a highly undulating sparsely distributed forest cover area. and 57 percent arable land and about 18 percent is notified as forest land average rainfall is 750 millimeter per annum and this takes place into 20 to 30 events during June to September.

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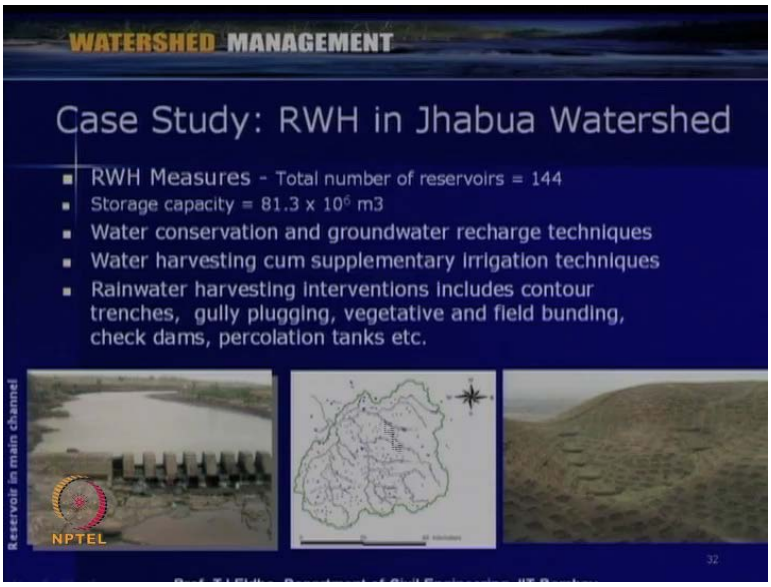

So, this is classified as a draught prone region. And moisture deficit is January to say so, we can see that pattern and this is the rainfall pattern for the area. with the help of the various government agencies and non government organization NGOS, various measures are adopted for the area like in construction of large number of check dams and then reservoirs storages about 144 storages storing this much water. And water conservation and ground water recharge techniques were applied say just like contour bunding and then like small trenches in various land forms. The rainwater harvesting interventions included contour trenches, gully plugging, vegetative and field bunding, check dams, percolation tanks, etcetera.

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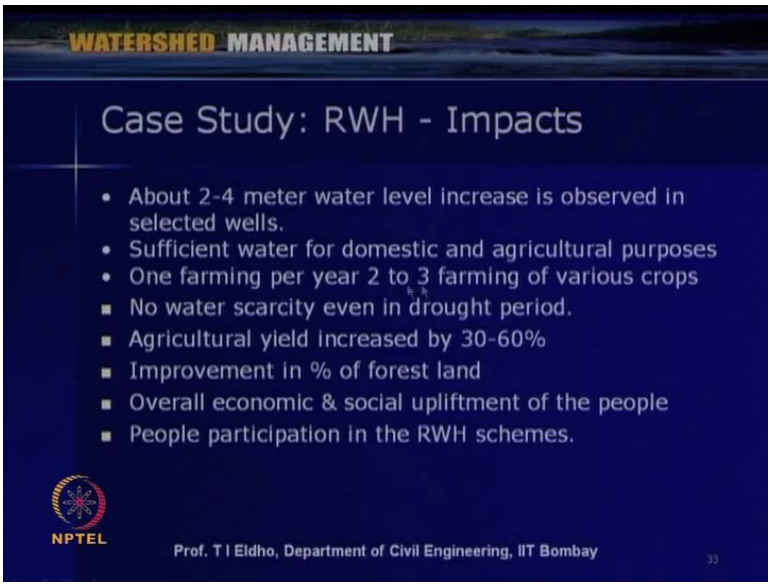

The impacts say, this project started in 1995 onwards. And then when we assess this in 2000 to 2003. The impact was say, huge impacts like about 2 to 4meter ground water level raised. Sufficient water for domestic and agriculture purposes is available in the area. One farming per area before rainwater harvesting, it was bound to 2 to 3 depending upon the area and crop. Then no water scarcity, even in draught period then agriculture yield increase 30 to 60 percent.

And there is the percentage forest land raised from 18 to 23 percent and overall economic and social upliftment happen in this area. Even migration of the people came to nil and the people participation in rainwater harvesting scheme this is one of the important aspect, as far as this jaguar watershed case study is concerned.

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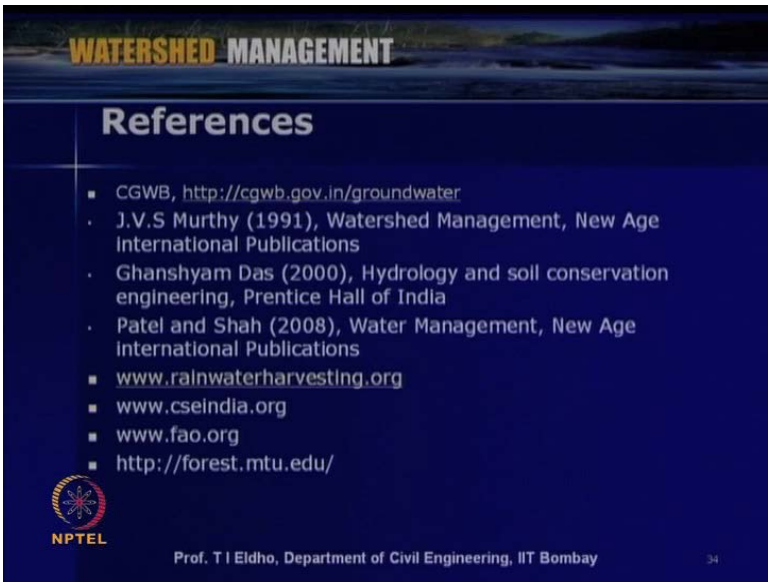

So, now before closing this lecture, some of the important references used in today's lectures lecture are listed here. And then one tutorial questions those who are going through this lecture. Describe the traditional water harvesting system adopted in India.

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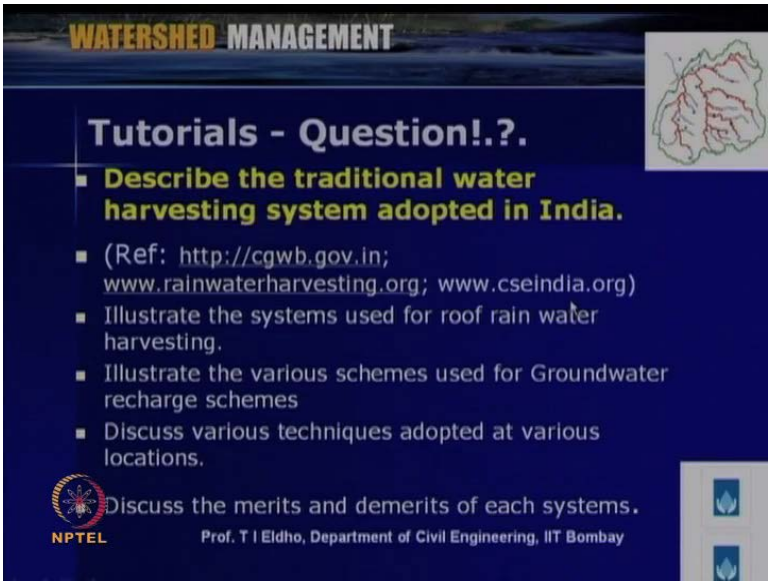

These details can be you can obtain through this websites. We can illustrate the system used for roof rainwater harvesting or ground water recharge schemes. And then discuss the various techniques and then discuss the merits and demerits of each system. So, these details you can see in this websites.

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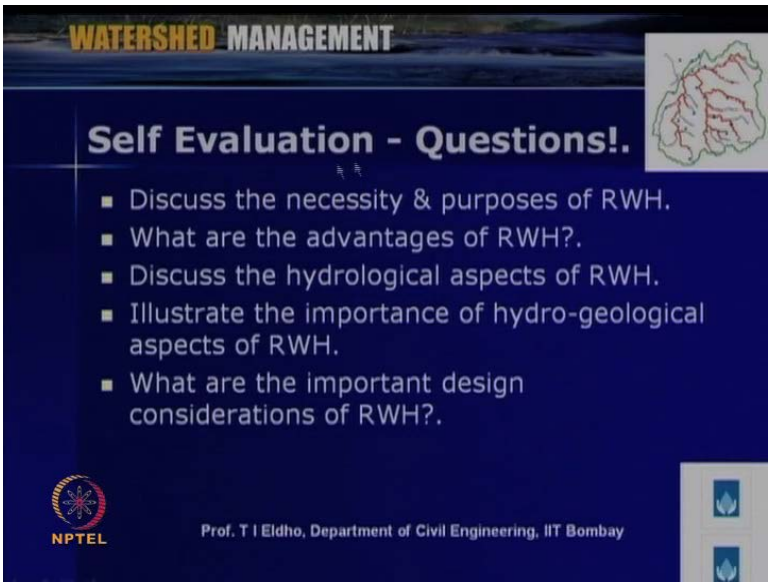

Then, a few self valuation questions, discuss the necessity and purpose of rainwater harvesting. What are the advantages of rainwater harvesting? Discuss the hydrological aspects of rainwater harvesting. Illustrate the importance of Hydrogeological aspects of rainwater harvesting. What are the important design considerations as far as rainwater harvesting is concerned?

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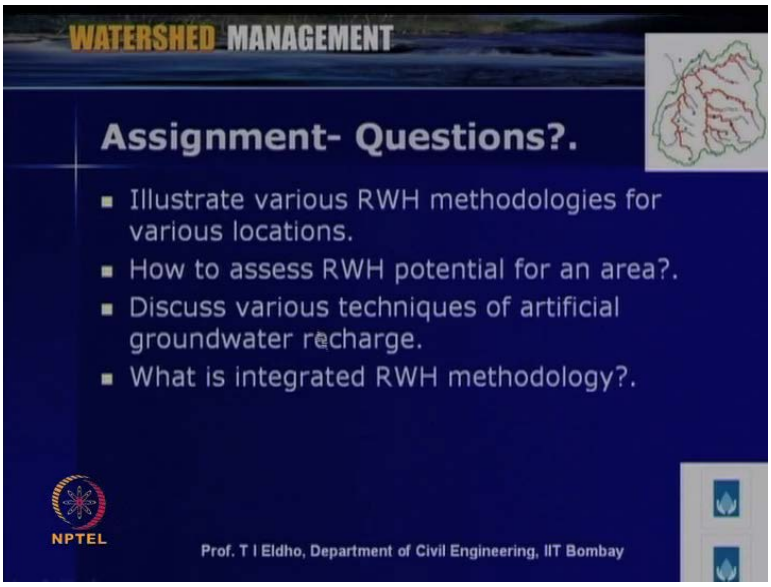

All these details for these questions, we have already discussed in today's lecture. And the few assignment questions like illustrate various rainwater harvesting methodologies are for various locations. How to asses rainwater harvesting potential for an area? Discuss various techniques of artificial groundwater recharge techniques. what is integrated rainwater harvesting methodology?

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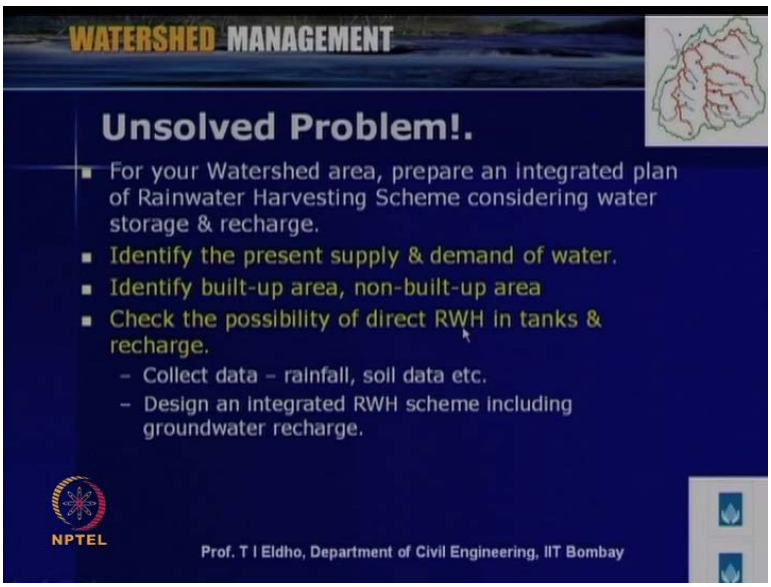

All these related answers we have discussed in today's lecture. For an unsolved problem for the listeners, for your watershed area prepare an integrated plan of rainwater harvesting scheme considering the water storage and recharge. You can identify the present supply and demand for your area. Identify built up area, non built area, then check the possibility of direct rainwater harvesting tanks and then recharging techniques.

All the data requirement you can collect like rainfall, soil data, then the agricultural pattern, etcetera. Then we can design an integrated rainwater harvesting scheme including the direct harvesting and storage and the ground water recharge. So, this based upon today's lecture you can do for your own area. In this lecture today, we discuss the rainwater harvesting. So, in the next lecture, further we continue some more aspects of rainwater harvesting and then particularly, we will discuss the rooftop rainwater harvesting. So, with this we will close for today. thank you very much