Watershed Management

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Lecture No. # 07

Watershed Management in Arid Regions and Strategic Planning

And welcome to the video course on watershed management in module 2, the on sustainable watershed approach and watershed management practices; lecture number 7, today we will discuss about watershed management in arid regions and strategic planning.

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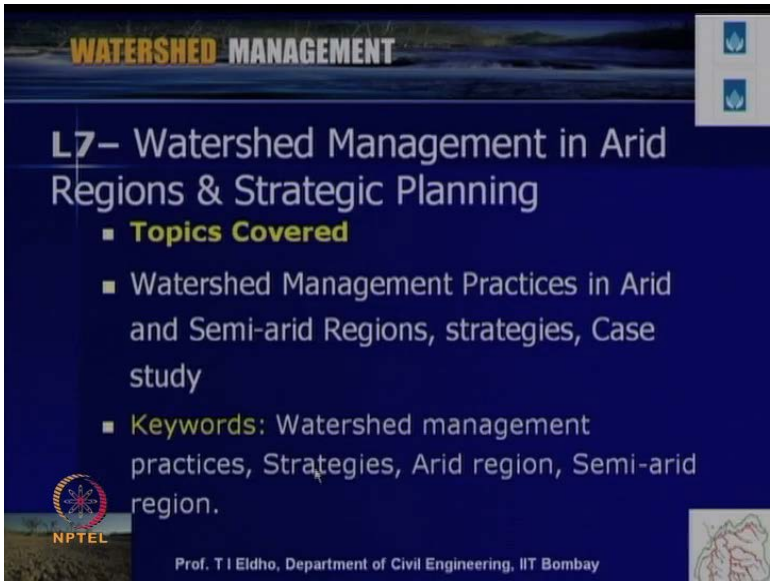

So, the important topics covered in this lecture include watershed management practices in arid and semi arid regions, various watershed management strategies, and we will discuss a case study. Some of the important keywords in today's lecture include watershed management practices, strategies, arid region, semi arid region.

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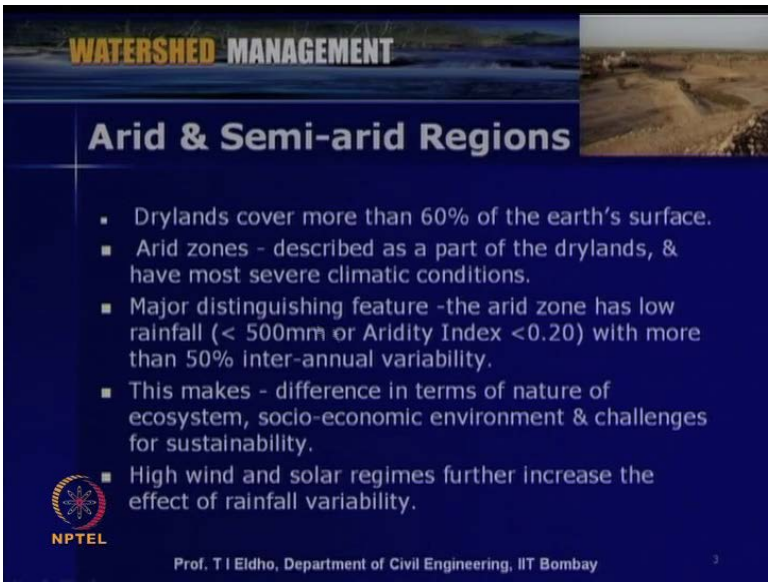

So now, let us discuss the watershed management practices in arid and semi arid regions. So, if you critically analyze the various lands, say land use or land's physiography, all over the world we can see that the dry lands cover more than 60 percent of the earth's surface. So, this 60 percent means not all the areas is all 60 percent is totally dry, but say some classifications says, dry lands cover more than 60 percent of the earth's surface. And arid zone describes this arid zone means, arid zones are described as a part of the dry lands, and have most severe climatic conditions. So, in the 60 percent some way or another way of say water shortage is there so, that is why we call this as dry lands; and out of this, say the arid zones are described as a part of the dry lands.

And are the major distinguishing feature of the arid zone includes arid zone has low rainfall, say most of the time average annual rainfall will be less than 500 millimeter or the aridity index will be less than 0.2. So, aridity index is used to identify the arid regions, arid lands in the dry lands region. So, where whenever this index is less than 0.2, we classify the the land as arid zone, and then with more than 50 percent inter annual variability. So, in this arid regions we can see that even though the average rainfall may be say 200 or 300 millimeter, but there is drastic variation inter say 50 percent inter annual variability takes place more than 50 percent.

So, this makes difference in terms of nature of eco system, socio economic environment and challenges for sustainability. So, we have discussed various issues related to

sustainability, so we can see that in these arid regions, it is so fragile ecosystem. So, lot of challenges will be there to say to when we discuss about watershed management in terms of socio economic and environmental aspects over land use aspects lot of challenges will be there. So, some of the peculiarities of this arid and semi arid regions include high winds and a solar regimes, and this further increase the effect of rainfall variability.

So, these are some of the important say issues or important aspects as far as arid and semi arid regions are considered. So, arid region will be within the say when the rainfall is less than 500 mm. So, semi arid region say we can say that it will be slightly more than 500 mm say may be up to 750 mm average annual rainfall; so but most of the time, the issues related to arid or semi arid regions will be some or another way similar.

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So, with this perspective, let us look into various issues - water related issues or land related issues as far as arid regions are considered. So, here all complexities say what we discussed as far as arid regions are concerned, there are so many complexities, land related complexities, the water related complexities, so all these makes a fragile ecosystem, in which small disturbances may cause great loss to the sustainability, which are sometimes irreversible. So, even if say for example, say in particular area, the average annual rainfall is say 300 mm. So, even there is a small changes taking place with respect to these availability, then there will be lot of problems; they say like a

severe drought problems, severe water shortage problems, there will be so many problems.

So, in these hot arid sorts of say, here we can see that say the small changes create a lot of problems, and hence this hot arid zones are economically, and environmentally disadvantaged with the unique problems. So, for a most of the arid or semi arid regions, say the problems when were we looking to various issues, it is a watershed related issues, then we can see that there will be, this issues will be unique. So, the ecosystems of these zones are highly fragile, with the large risks that course.

So, as I mentioned even small changes can create lot of problems to the ecosystem, and a severe impediments to development programs; so, that is the another issue. So, say of course, there is problem related to land, then problems related to water. So, the water resources related problems are there. So, within this constrains, say when since the ecosystems are so fragile. So, as far as development programs are concerned, there will be severe problems; we have to be very careful in the planning. So, of the total land area in the world, we can classify about 18.8 percent say as a arid zones. And these arid zones are diverse in terms of climate, soils, vegetation, animals and the lifestyles, and the activities of the people.

So, when we have discussed about the arid zones, there is say unique problems are there, and then say arid or semi arid regions say its problems related to water or land or say soil erosion problem due to wind or other related issues. So, the problems will be unique, and then say even a small change can create a lot of problems as far as the economic planning or the watershed management plans are considered.

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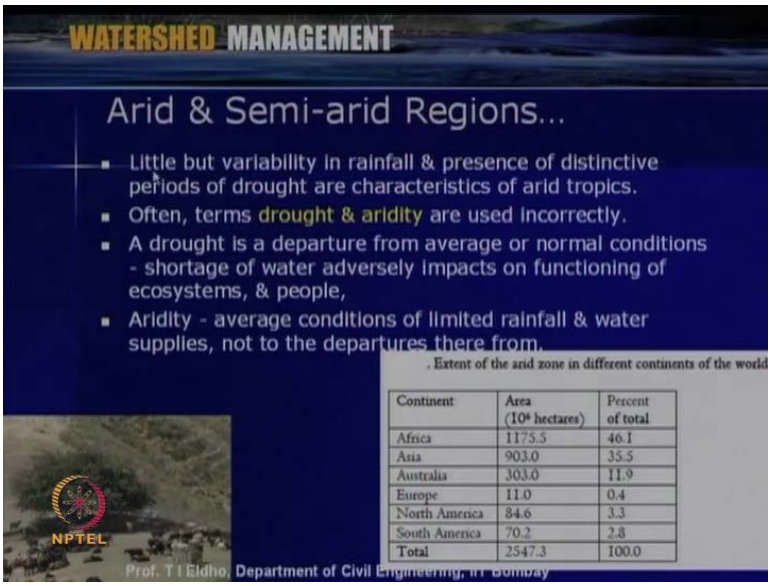

So, as far as arid and semi-arid are concerned, so little but variability in rainfall, and presence of distinctive periods of droughts are characteristics of these areas. So, often say we call sometimes drought or sometimes aridity, so but say as far as these terms are concerned, there will be lot of confusion. So, as far as a drought is concerned, we can define it as a departure from average or normal conditions that means the shortage of water adversely impacts on functioning of the ecosystems and the people of the areas. So, that is a drought, but as far as aridity is concerned, the average conditions of limited rainfall and water supplies, there will not be much departure from the whatever, say the available in that particular region. So, the this is the difference between a drought and the aridity. So, according to the conditions we have to use the term appropriately whether a either has drought or aridity.

So, now as far as the world is concerned, the extent of arid zone in different continents are listed here say for example, Africa say say 1175 million hectares. So, for example, about 46.1 percent of the total area area we can classify as arid. So, Asia is concerned about 35.5 percent, Australia 11.9 percent, Europe only 0.4 percent, North America 3.3 percent, South America 2.8 percent. So, like this, say the extents of arid zone in different continents are varying; so according to the space I mean, from different continents to different continents or say one country to another country, lot of variation are there as far as the arid zone statistics is concerned.

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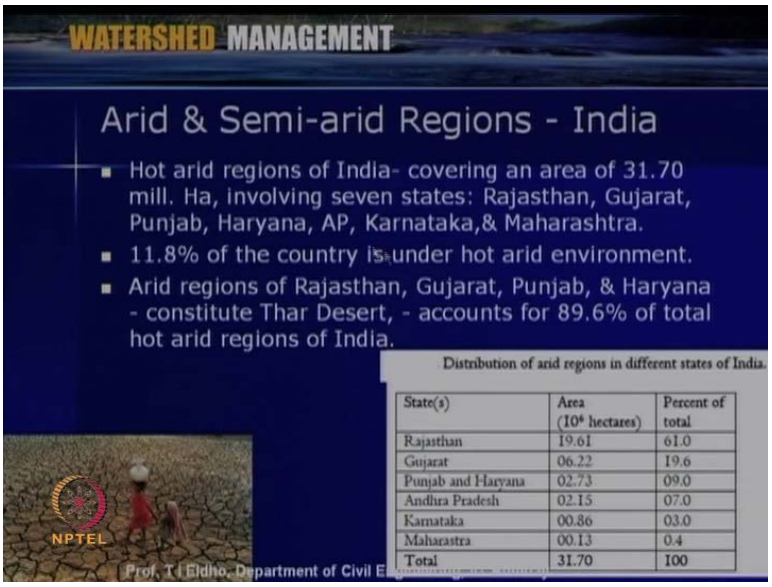

So, say for example, India is concerned when we discuss about India say hot arid regions of India say cover about 31.7 million hectares involving mainly in 7 states, including Rajasthan, Gujarat, Punjab, Haryana, Andhra Pradesh, Karnataka and Maharashtra. So, about 11.8 percent of the country is under hot arid environments; and the arid regions of Rajasthan, Gujarat, Punjab and Haryana say which constitute the so-called Thar Desert; and this account say more than 89 percent of the total hot arid regions of India. So, here we have to differentiate the hot arid regions and say normal arid regions.

So, here say as far as India is concerned, the arid regions distribution is shown in this table say for example, in Rajasthan about say 19.61 million hectares and 61 percent. So, Gujarat 19.6 percent, Punjab and Haryana 9 percent, Andhra Pradesh 7 percent, Karnataka 3 percent, Maharashtra 0.4 percent like this. So, this shows the statistic as far as distribution of arid regions as far as India is concerned.

So, so far we have seen the distribution of arid regions throughout the world and India is concerned. So, we can see that a lot of variations from one states to another state or from one country to another country. But as far as the problems of the aridity or the drought are concerned, say the land related or water related problems for this most of these regions are unique. So, that way say we can say whenever we discuss in terms of watershed management, most of these issues are common as far as the most of the arid or semi-arid regions are concerned. So, now let us see, what are the main issues as far as

watershed management issues are concerned, what are the main issues in arid and semi-arid regions?

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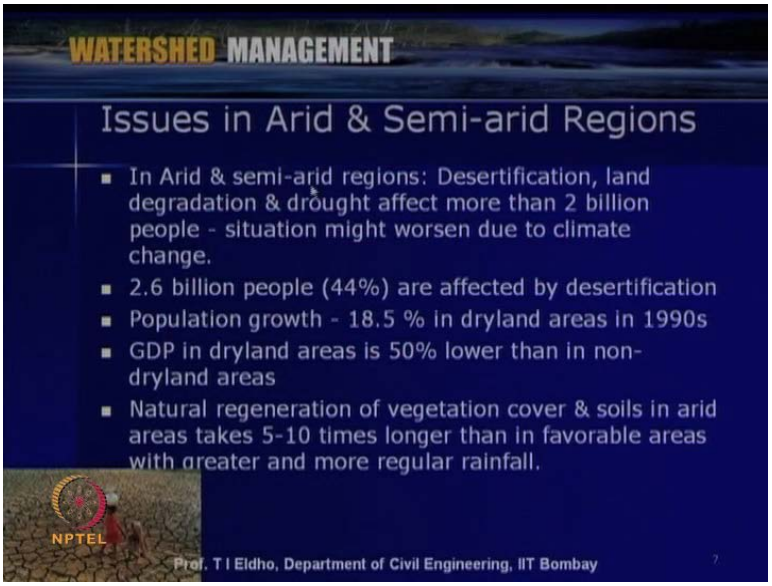

So, in arid and semi-arid region, so some of the major issues include desertification, land degradation, drought affect more than say about 2 billion people throughout the world, and situation might worsen due to the climate change. So, now now now in the recently we are discussing about the climate change; so when the climate change say issues are concerned, you can see that a the temperature raises, and then the say even though some some regions are inform may increase, but say overall say the total available rainfall will be obtained in a few events. So, that way the drought problems will be increasing; so and then say the most of the issues as far as arid or semi-arid regions, there will be the more problems as far as the temperature or as far as the water availability is concerned.

So, as far as arid and semi-arid regions are concerned 2.6 billion people are affected by desertification, and the population growth as far 1990 is concerned 18.5 percent in dry land areas are this the growth is there. And the GDP is concerned in dry land areas gross domestic product in areas is about 50 percent lower than in non dry land areas. So, this shows the economic statistic or economic status of the people of the arid or semi-arid regions or the dry land regions. So, you can see that compared to non dry land areas say the GDP is 50 percent lower. So now, in the natural regeneration of vegetation cover and

soils in arid areas takes 5 to 10 times longer than in favorable areas with greater and more regular rainfall.

So, when we compare the arid regions and non arid regions say we are already seen the GDP; so similarly say when we are trying to regenerate the vegetation or when we are intervening in terms of watershed management practices, and then we can see that say we have to put more efforts we have to say wait for long time to see the effects, so about 5 to 10 times longer than in favorable areas say with a greater and more regular rainfall. So, these are the main issues as far as watershed management is concerned in arid and a semi-arid regions.

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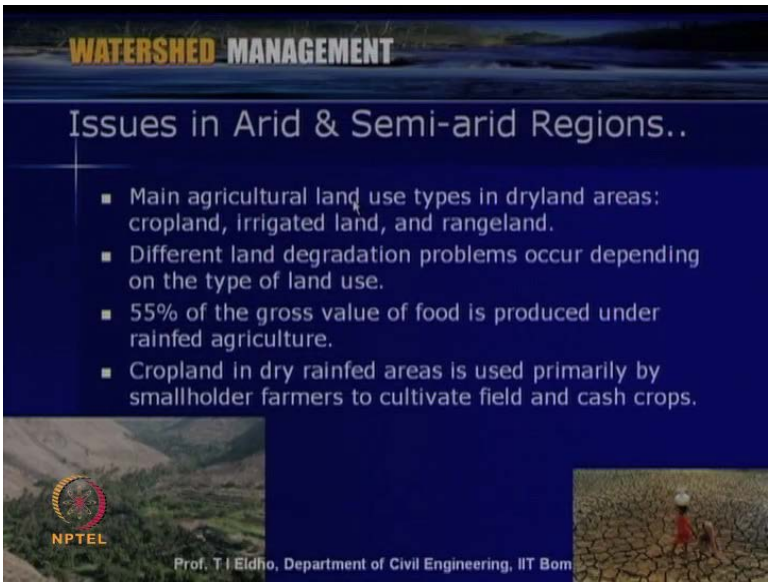

Also the main agricultural land use types in dry land areas say like a cropland, irrigated land and a rangeland. So, there are lot of issues as far as the agricultural a area is concerned. So, different land degradation problems occur, depending upon the type of land use in the arid or semi-arid regions 55 percent of the gross value of the food is produced under rainfed agriculture in the say arid and semi-arid regions. Cropland in a say, dry rainfed areas is used primarily by smaller small holder farmers to cultivate fields and cash crops.

So, as far as agriculture is concerned, most of the areas in the arid or semi-arid regions say about 55 more than 55 percent is a rainfed agriculture. So, very few areas are having

the reaction facilities. So, due to all these reasons the agriculture practice the agriculture is concerned major issues are there, which we have to address whenever we discuss in terms of watershed management practices. So now, within this perspective of the various issues, which we have discussed so far, as far as the arid and semi-arid regions are concerned; let us see what are the major challenges as far as the watershed management is concerned.

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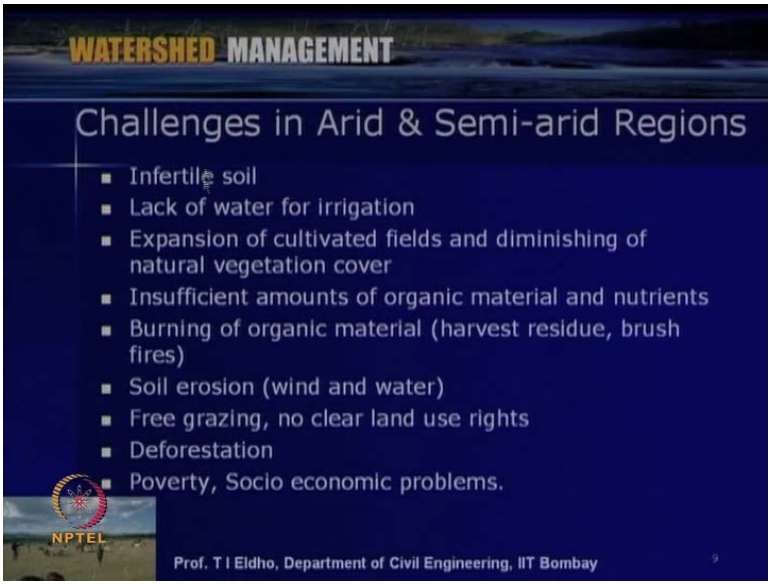

So, some some of the important challenges are listed here. So, like the land is concerned, the soil is infertile; then lack of water for irrigation; then expansion of cultivated and diminishing of a natural vegetation cover. So, say most of the area, say the people are trying to cultivate, so the fields are in developing stage; and most of the natural vegetations are diminishing; and then insufficient amounts of organic material and nutrients, so this creates a lot of problems as far as the plant growth is concerned. Then in many of the areas, the cultivated areas burning of organic materials like a harvest residue, brush fires etcetera.

Then soil erosions. So, this is another major issue as far as the arid regions are concerned. So, mainly in arid regions, the soil erosion is as we discussed in the last lecture, it will be mainly due to the wind force; so wind velocity. So, so this whenever the high wind comes, so most of the say the this soil will be especially, in sandy in

nature, and this sand will be say transported with the wind, and it will be deposited in some faraway places.

And then, some of the other challenges say as far as the arid and semi arid regions are concerned free grazing. So, there is no clear and land use rights, and whatever existing for us only scanty forests are there, and whatever existing for us concerned, deforestation is a major issue in most of the arid and semi-arid regions; and then all this leads to poverty and socio economic problems as far as the people residing in these regions. So, these are some of the major challenges as far as the arid and semi-arid regions concerned in terms of the watershed management plans, which we can consider for these areas.

So, now with let us discuss the various issues or with respect to the various challenges as far as the arid arid and semi-arid regions are concerned; how we can sort it or say solve this issues or a what kind of watershed management within the perspective watershed management practices, how what we can do as far as the arid and semi-arid regions are concerned.

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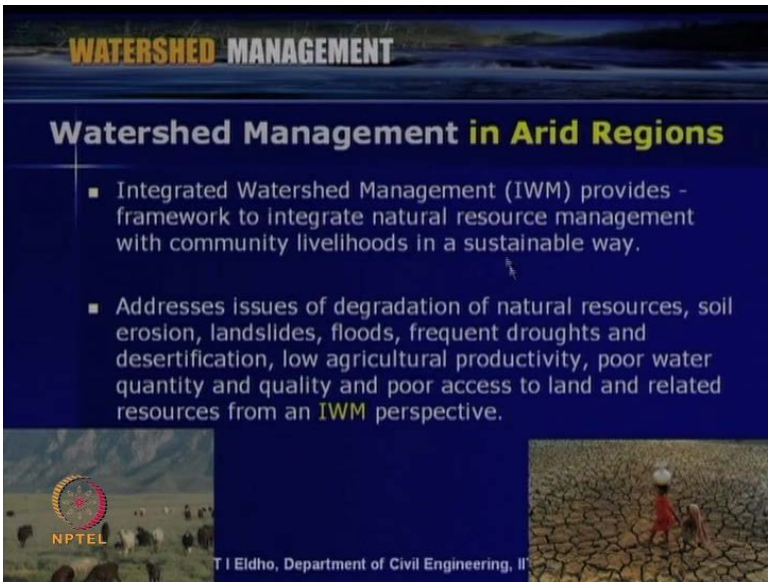

So, now in this slide, we can see watershed management in arid regions. So, here earlier we have discussed the integrated watershed management practices, project or the approaches. So, the say if we can integrate to various aspects, which we discussed earlier, so then there it will be a good solution as far as the arid regions are concerned.

So, this IWM or Integrated Watershed Management approach provides a framework to integrate natural resource management with community livelihoods in a sustainable way. So, this is our main emphasis as far as the watershed management in arid regions are considered.

So, within the perspective of IWM, we try to address issues of degradation of natural resources, soil erosion, and landslides, floods, frequent droughts, and desertification, and low agricultural productivity, poor water quantity, and quality, and poor access to land and related resources from an IWM perspective integrated watershed management perspective. So, most of the issues most of the things, which we discussed whatever we are trying to integrate various aspects as far as watershed management is concerned. So, if you can integrate same like a land related, water related or the people related, then say we can see that we can have a better say watershed management plans as far as the arid regions are concerned. So, as we discussed earlier compared to normal area the ecosystems of the arid regions are so fragile. So, we should be very careful, when we try to make plans within the perspective of integrated watershed management say as far as the arid regions are concerned.

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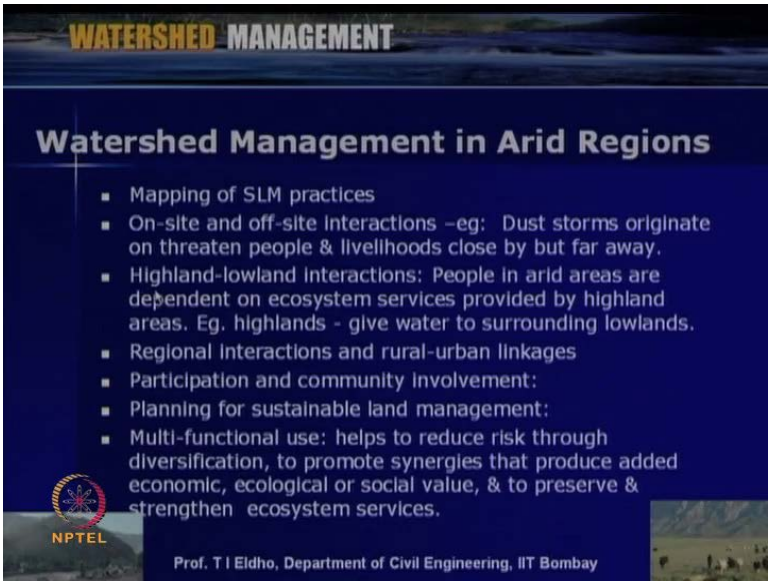

So, some of the important IWM practices possible are listed here in this slide. So, the watershed management in arid regions; so, first one is a see this sustainable land management practices. So, we can start with the mapping of sustainable land

management practices. Then on site and off sites interactions say as we discuss say for example, if dust storms takes place that a originates from a location, and that can threaten people and livelihoods close by, but quite far away also. So, it is a not only a localized issue, but far distance also the problems can be there.

And then also say as far as the arid regions are concerned or semi arid regions are concerned, lot of interaction will be there between highlands and or lowlands. So, people in arid areas are dependent on ecosystem services provided by high land areas say for example, if this is a high land or this is the high land. So, then we can see that say if we can do through watershed management practice or rain water harvesting, if we can harvest lot of water in this hilly region, so that will be a source of water to the lowland areas. So, the highlands give water for to the surrounding lowlands. So, like that we can look into the highland lowland interactions.

And then the next thing is say there can be regional interactions and rural urban linkages. So, you can see that a say whatever products are made in a, agricultural products made in a rural area, that will be transported to the urban areas, and from urban areas many of the consumable things will be transported to the rural areas. And then a participation and the community involvement - So, these are some of the as we discussed earlier as far as integrated watershed management plan is concerned people participation is very important, and community involvement is also very important, so that we can look for sustainable say watershed management or sustainable land management.

So, when we look into the various problems and various issues, we can see that a say many of this issues, we have to we should have a multi faced approach or multi functional approach. So, a multifunctional approach and multi functional use helps to reduce the risk through diversification to promote synergies that produce added economic, ecological or social value and to preserve and strengthen the ecosystem services. So, only issues that the ecosystem is so fragile, so we should be very careful while intervening in any of these arid or semi-arid regions. So, as far as watershed management plans, we have to study in detail, and then see we have to map the sustainable land management practices, and then we have to start, we have to say put appropriate plans by considering all the issues of the considered watershed.

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So, now let us discuss in detail about the sustainable land management. So, sustainable land management in arid regions helps to increase food security primarily for small holder, so small holder farmers. So, we have seen that most of the people living in a arid regions are small holder farmers. So, the main aim of sustainable land management is to increase the food security. And then provide local energy local energy say for example, in terms of solar energy, wind energy, etcetera; then provide local fresh and clean water. So, this we can achieve through say locally based rain water harvesting or say local say wells, which are which obtain water through say recharges.

Then mitigate soil degradation. So, soil degradation is a major issue as far as the land is concerned. So, the sustainable land management practices we have to mitigate the various soil degradation problems, when increase the soil moisture. So, we can see that a say when the soil moisture is improved, then the agricultural yield will be more or we can say more land we can use for agriculture purposes. So, that way, so increasing soil moisture is very important. So, we have to look in terms of soil developments and functions as far as the in terms of sustainable land management is concerned.

And then enhance a primary production and nutrient cycling. So, this is also a very important as far as the sustainable land management is concerned. And then preserve biodiversity at the farm level through agro forestry, intercropping, fallow and preservation of locally adapted seed. So, these are some of the things, which you can be

say we can plan as far as the sustainable land management is concerned. So, we have to preserve the biodiversity, then say like agriculture is concerned, we can go for intercropping, then preservation of locally adapted seed.

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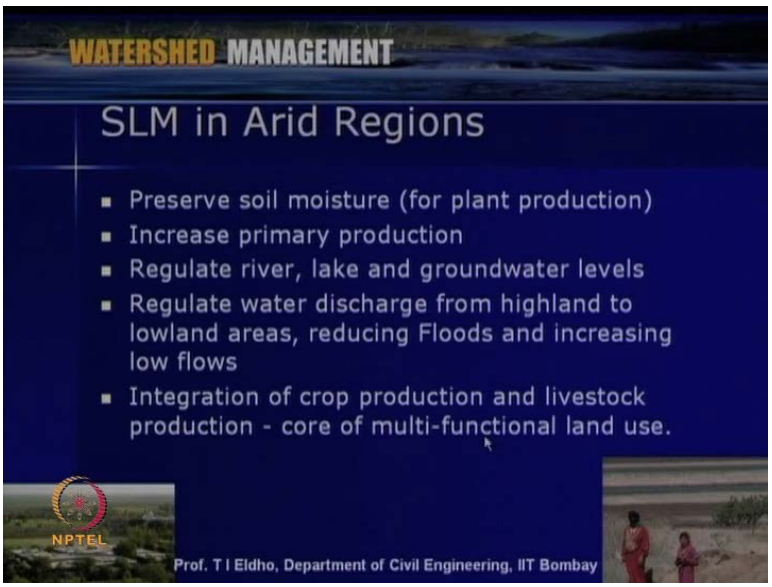

So, now say some of the important things, which we can do as far as the sustainable land management in arid regions are concerned, say we can do say many things related to say to preserve soil moisture, so that a better a plant production will takes place. And then we can increase the primary productions say production say in terms of water or other other resources, then say if any river is there we can regulate the river lake and a ground water levels, so that we can achieve sustainable land management in terms of watershed management practices.

Then we can regulate water discharge from highland to lowland areas, reducing floods and increasing the low flows in the in the streams or the channels are concerned. And then we can integrate the crop production and livestock production. So, these are some of the as far as multi functional land is concerned, these are this is the core of the multi functional land use that means, integration of crop production and the livestock production, so that the income of the people will be increased; so the through this we can achieve the poverty alleviation, and then better say sustainable land management is possible.

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So, now say as we discussed a there are so many issues are there. So, as far as land use is concerned, we can see that it is a multi functional. So, multi functional means, say here we have to see that the various issues as far as the land use is concerned, say like the production of food and cash crops, say which one we have to give priority; so accordingly we have to manage. Then irrigated land, so wherever possible possibility of irrigation is there. So, dry land areas with a high potential for ground water, and surface water are used to cultivate crops fruits and vegetables. So, we have to plan the agriculture in such a way that whether there is any option for irrigation, whether a sufficient ground water we can pump it, pump out, and then we can increase the possibility of irrigation. So, that way we have to see as far as the irrigated land is concerned.

Now if you consider rangeland. So, the here the livestock production is the priority as far as range land is concerned. So, livestock management reduces risk while rotation of grazing land ensures that vegetation cover is preserved. So, rangeland where the we cannot utilize much much of this area for the agriculture purposes, so that we we can use for livestock production. So, there say as far as you say for the sustainable land management is concerned, we have to see that we can implement them the rotation of grazing, so that the gross will be regenerated say if we can go for rotation of grazing.

Then dry land areas are concerned dry land areas react with particular sensitivity to disturbances in the water and biomass cycles. So, regulating and supportive functions are seriously affected by inappropriate management of the soil and the vegetation cover. So, these are some of the issues, which we have to deal as multi functional land use as far as the arid or semi-arid regions are concerned.

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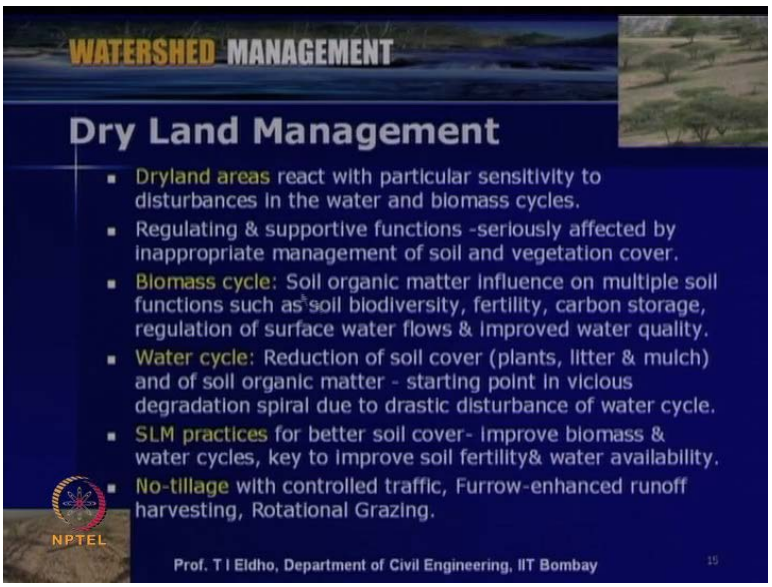

So, now, with this perspective within this perspective let us look into the dry land management. So, what we can do as far as the dry land is concerned how effectively we can manage the available land. So, some of the important things what we can be done are listed here. So, like a dry land areas react with a particular sensitivity to disturbances in the water and biomass cycles. So, regulating and supportive functions seriously affected by inappropriate management of soil and vegetation cover. So, we should be very careful to see that the regulating and supportive functions are planned properly.

And then as far as biomass cycle is concerned, soil organic matter influence on multiple soil functions such as soil biodiversity, fertility, carbon storage, regulation of surface water flows and improved water quality. So, the biomass cycle aspects we have to consider as far as the dry land management is concerned, and then water cycle. So, the water availability is a very less, so that way we should be very careful. So, reduction of soil cover like a related to plants, litter and mulch, and of soil organic matter, so are the starting point in a in the vicious degradation spiral, so due to drastic disturbance of the

water cycle. So, the within the available water, I mean already in the dry land say the water it is a say very, very less. So accordingly, we have to see that within the available water resource say we have to improve the soil moisture, so that we can go for say better agricultural practices.

And then as far as dry land management is concerned, so like sustainable land management practices, which we discussed in the previous slide. So, we can utilize this for better soil cover, improve biomass and water cycles, and these are the key to improve soil fertility and the water availability as far as the particular area is concerned. And then no tillage with control traffic; and then furrow enhanced run off like this, the run off harvesting and rotational grazing. So, these these are some of the issues, which we can or the things, which we can do as far as a dry land management is concerned, say within a arid region.

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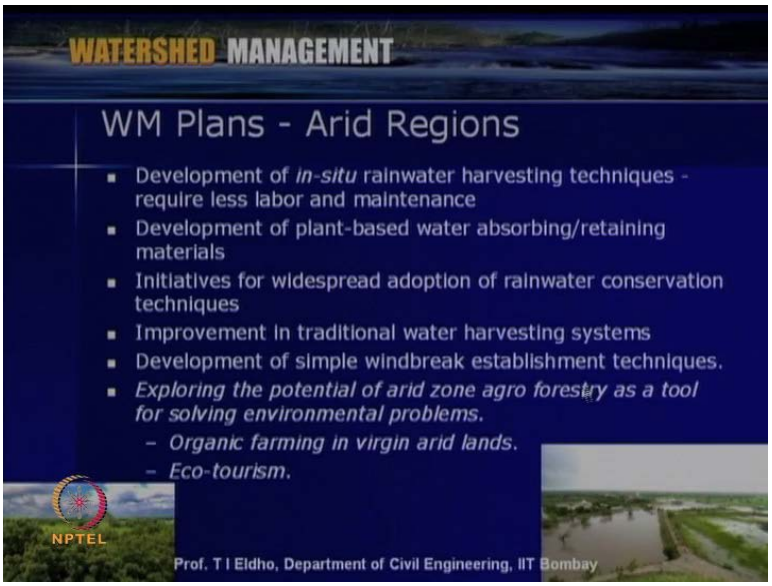

So, now say let us look into what are the possible watershed management plans as far as the arid regions are concerned. So, as we have discussed the main issues are the soil is not fertile, so the land is say land related issues, then we have the water availabilities very, very less. So, water related problems are there, then the where same the people say their total income is much, much less. So, there are so many issues as we discuss. So, within this perspective, so how we can go for better watershed management plans. So, let us look let us discuss the these issues. So, as far as watershed management plans are

concerned, development of in-situ rain water harvesting techniques. So, that is very important as far as the arid regions are concerned.

So this, so we should look for various practices, which require less labor and maintenance; and then the cost also should be very less for the considered project. And so, we have to see that say as far as the particular area is concerned whether we can use the local labor and local available material as far as the various water harvesting techniques are concerned. Then developments of plant based water absorbing or retaining materials; so say depending upon the area we can develop with the some particular types of plants, which we can absorb water depending upon the say rainy season or rain must be depending upon the rain. So, this water will be absorbed by the plants and that will be retained.

Then initiatives for widespread adoption of rainwater conservation techniques; so hence, we can see that say for example, this is a dry land area, where a number of projects have been implemented as far as the rainwater conservation is concerned like check dams, then Nala Bunding etcetera. So, we can look into the say a large number of rain water conservation techniques. Then improvement in traditional water harvesting system - so, as we have discussed earlier say water harvesting system was there say for centuries, and you know say we have to reactivate some of these traditional harvesting systems, which are very much suitable for this arid regions. So, depending upon the locality, we can say choose particular say water harvesting system for that particular area.

Then developments of simple wind break establishment techniques. So, as we discussed for most of the arid region, the soil erosion due to wind is a major problem. So, say we have to reduce the wind speed, so that the soil erosion will be reduced. So, we have to develop simple wind break as technique like a say, we can go for say plants, which we can reduce the speed of the wind say one ridges, so that that you can reduce the soil erosion problems.

And then also we can as say as far as the watershed management plans are concerned we can explore the potential of arid zone, agro forestry as a tool for solving the environmental problems. So, we can go for better agro forestry, so like shown in this photograph. So, that can solve most of the issues as watershed management plan plans are concerned. Then also we can go for organic farming in virgin arid lands, and then

another source of income for the local people be eco tourism. So, eco tourism means say we can develop the particular arid region particular arid village, and then we can give facilities for the local or international tourist, so that the local people can earn money through various means. So, eco tourism is one of the important aspects, which we can promote in many of the areas.

So, now say let us look into what are the possible watershed management practices as far as the arid regions are concerned. So, say depending upon the how say we have we have as far as the arid region is concerned, as we classified most of the time, the average annual rainfall will be less than 500 mm. So, accordingly say depending upon how much rainfall is available, so we can go for particular watershed management practice for the considered area.

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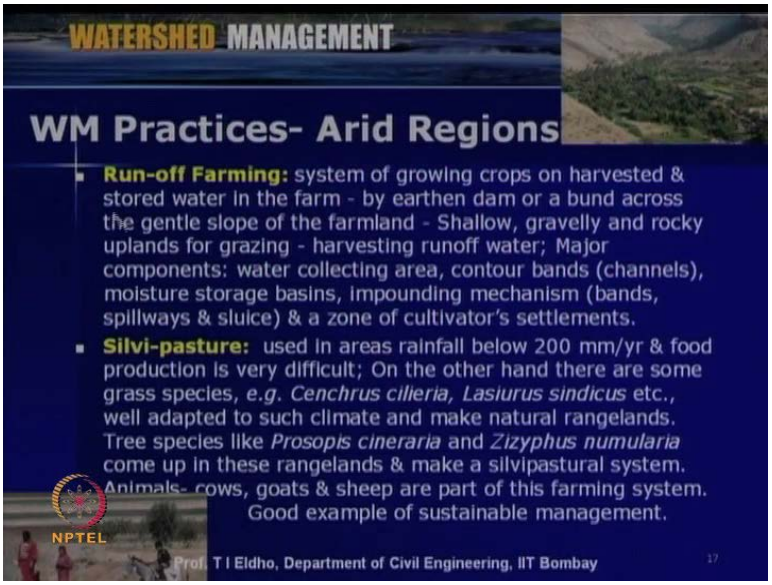

So, few of the possible practices are listed here and discussed. So, first one is a run-off farming. So, here say depending upon the rainfall conditions, so here, we can go for runoff farming. So, this is a system growing crops on harvested and stored water in the farm by earthen dam or a bund across the gentle slope of the farmland. So, this is a so in this say runoff farming, so the shallow gravelly and rocky uplands; so like this rocky uplands shallow regions, so this we can, this area we can keep for grazing. And then we can harvest the runoff water coming from the uplands using say, using various water harvesting techniques, say and then we can collect the area collect the water. So, water

collecting area then we can use go for contour bands say that means, say using channels according to the contour, then moist storage basins, then impounding mechanism like bands, spillways and sluice, and a zone of for cultivator's settlements.

So, like this, say if the rainfall is say somewhat good like a say 300 to 500 mm per annum, then we can go for better farming practices, and then we can go for the say various rainwater harvesting schemes, and then we can classify the land use as far as the upper land, then lower land is concerned and lower land we can use for farming, and then people settlement, and then upper land we can go for grazing, and then also we can use it for the say rain water harvesting as far as the particular area is concerned. So, that is what is known as runoff farming.

So, then the area is where the rainfall is a say for example, below 200 mm per year, so that we can go for a scheme called a Silvi-pasture. So, here the silvi-pasture is used in areas rainfall below 200 mm per year, and a food production is a very difficult in this region. So, on the other hand, there are some grass species which will be going in this area. So, for example, this Cenchrus cilieria say like that these scientific names of some of the grass species. And these are well adapted to such climate and make a natural rangelands. So, the tree species like a Prosopis cineraria and say Zizyphus numularia come up in these rangelands. So, this kind of plants grows in this area, and makes a silvipastural system. So, this say once these type of plant or grass species grows in the area, so then we call such a system as Silvipastural system.

And then animals like cows, goats and sheep's are part of this farming system. So, these animals can graze in this region; and then the animal products say like milk eggs meat etcetera can be used by the local people. So, that will be their major income. So, here we can see that this is a good example of sustainable management; so depending upon the area since the rainfall is very low, so we utilize the plantations possible plantations, and then grass species; and then depending upon that we say grow the animals, and then we get the income from this animals. So, that is so-called a silvipasture.

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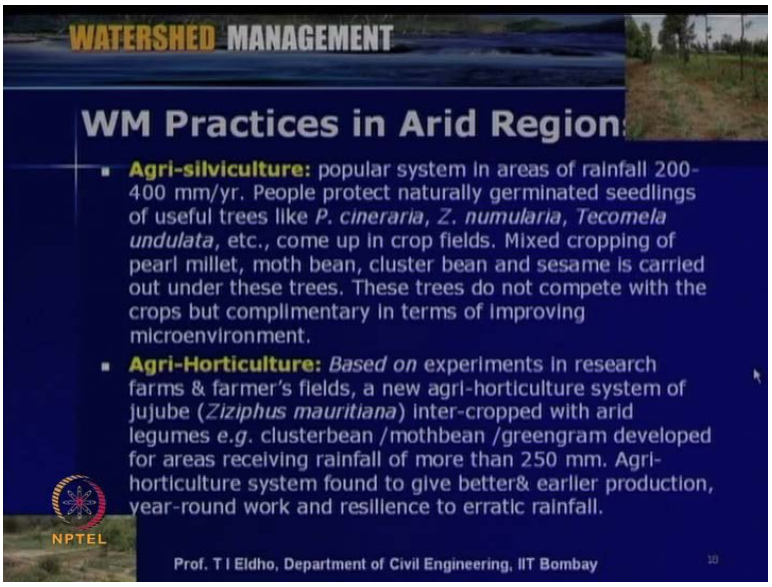

And then another say system is called Agri-Silviculture. So, this is mainly a popular system in areas of rainfall between 200 to 400 mm per year. So, people protect naturally germinated seedlings of useful trees like a P. cineraria then Z. numularia like that. So, these trees come up in crop fields, and then we can go for mixed cropping of pearl millet, moth bean, cluster bean, and sesame, these are all carried out under these trees. So, you can see that big trees will be there like in this photograph. And then small plants like a beans, pearl millet etcetera, can be grown under the shade of these trees. So, these trees do not compete with the crops, but complimentary in terms of improving the microenvironment. So, that is so-called the Agri-Silviculture system.

And then the last one is so-called a Agri-Horticulture system. So, say throughout the world, number of research studies were conducted, and based on experiments in research farms and farmer's fields, a new Agri-Horticulture system of a say, so-called jujube say it is in scientific name Ziziphus mauritania. So, jujube intercropped with ah arid legumes like a cluster bean, moth bean, green gram these are developed for areas receiving rainfall of more than 250 mm per year. And Agri-Horticulture system found to give better and a earlier production, so that we can go for year round work, and this will be resilience to erratic rainfall. So, this is so-called Agri-Horticulture systems, which are possible in arid region.

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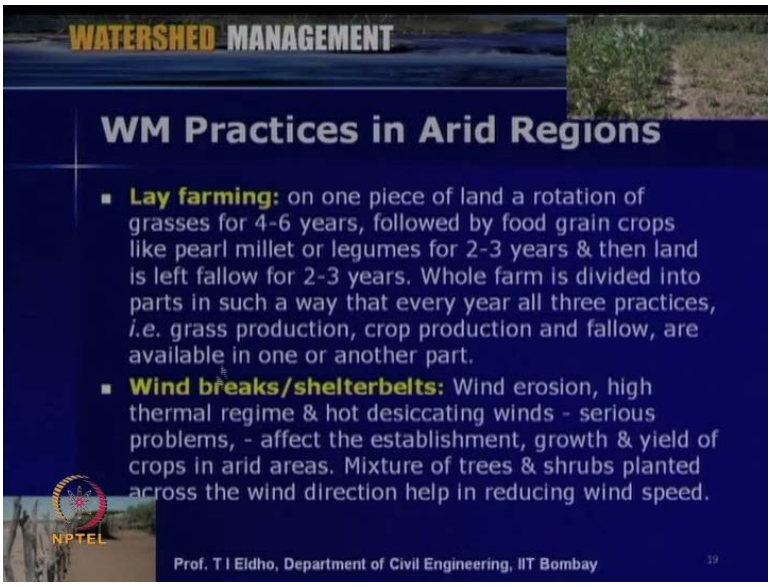

And also say like as far as the watershed management practices are concerned, we can go for lay farming. So, say for example, lay farming the concept we have lay farming is on one piece of land, rotation of grasses for 4 to 6 years are implemented, followed by food grain crops like a pearl millet or legumes for 2 - 3 years. And then land is left fallow for 2 - 3 years, and whole farm is divided into parts in such a way that every year all these three practices we can continue. So, like a grass production, crop production and fallow are available in one or another part of the land. So, this system is called a lay farming system.

And then as far as the major problem of like soil erosion due to winds, we can develop wind breaks or shelter belts; say wind erosion, high thermal regime, and hot desiccating winds, serious problems in the arid regions. So here, we can have a mixture of trees and shrubs planted across the wind direction like shown here; so, in reducing the wind speed. So, this is another watershed management practice in arid region.

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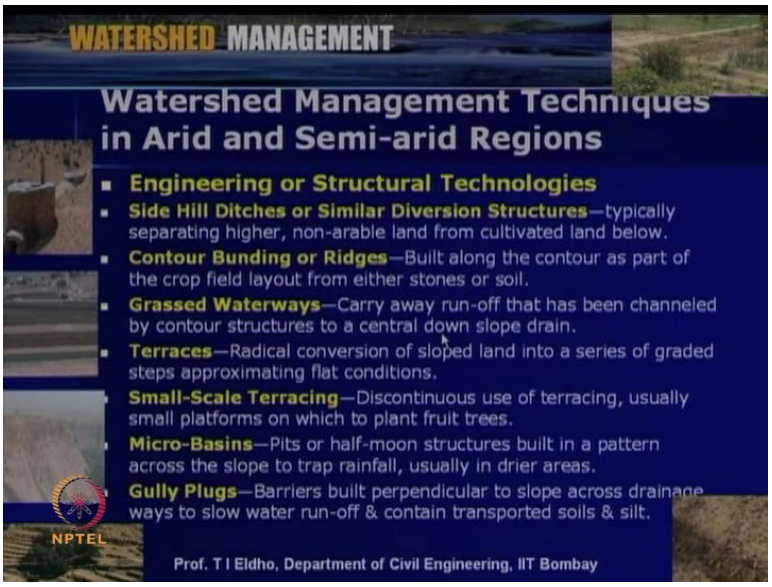

So, now say let us look into various techniques, which we can utilize in terms of engineer techniques or structural technologies as far as arid and semi-arid regions are concerned; some of the important say engineering technologies are listed here, as far as watershed management is concerned, for the arid or semi-arid regions. So, these technologies include like a side hill ditches or similar diversion structures, so this we can use non arable land from cultivated land below.

Then we can go for contour bunding or ridges as we discussed as far as say watershed management practice is concerned. So, these are built along the contour as a part of the crop field. Then grassed water ways; so which carry away run-off that has been channeled by contour structures. Then we can say go for terraces like this, we can have terraces, so radical conversion of sloped land into series of graded steps. Then we can go for small scale terracing depending upon the area. Then also we can go for micro basins like we can have pits or half moon structures say as part of rain water harvesting. Then we can go for gully plugs like barriers built perpendicular to slope across drainage ways. So, these are some of the engineering or structure technologies, which are possible as far as arid or semi-arid regions are concerned.

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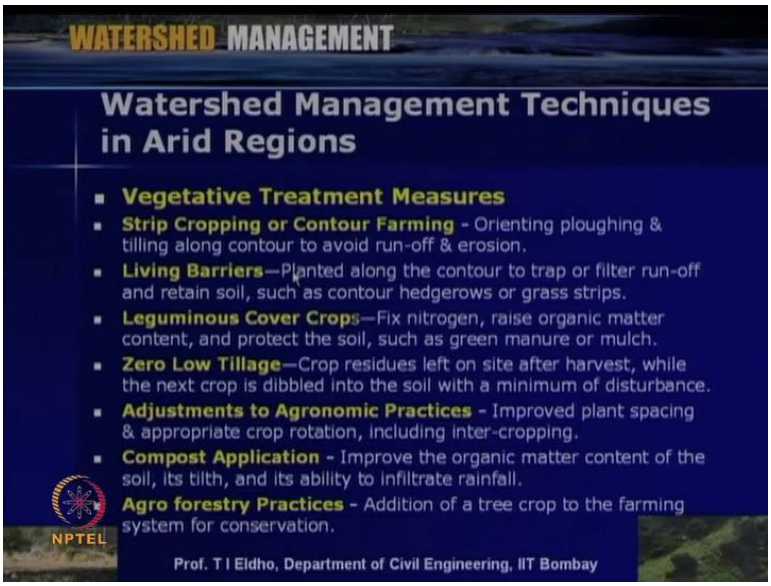

And then also we can give a vegetative treatment measures as far as the arid or semi-arid regions are concerned, like some of the important vegetative treatment possible in the areas and arid regions are listed here like strip cropping or contour farming; then living barriers; then leguminous cover crops; then zero low tillage; then adjustment to agronomic practices like improved plant spacing and appropriate crop rotation including inter cropping; then we can go for compost application like improve the organic matter content of the soil; then we can go for agro forestry practices. So, these are some of the vegetative treatment measures as far as the arid regions are concerned.

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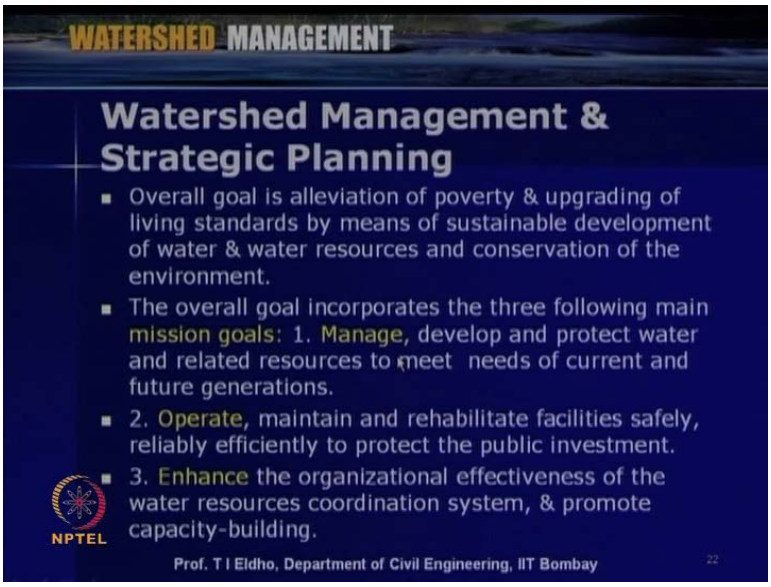

So, with this a now say what we are discussed so far is say what are the possible watershed management plans as far as the arid or semi-arid regions are concerned. So, there are unique problems as far as the say the arid or semi-arid regions are concerned; and then we can have unique solutions also depending upon the area, depending upon the precipitation available for the particular area.

So, now let us go to the second section in this lecture, so-called say watershed management strategies and strategic planning. So, here we will discuss not for arid regions, but in a holistic way, what are the important watershed strategies as far as watershed management is concerned and what is strategic planning. So, here as discussed here, say overall goal for watershed management is alleviation of poverty, and upgrading of living standards by means of sustainable development of water, water resources and conservation of the environment. So, all the resources we are say developing in a sustainable way, so that we can alleviate the poverty, and then upgrade the living standards of the people.

So, the overall goal incorporates basically three mission goals, say first one is manage, develop and protect water and related resources to meet needs of current and future generations; so, this is the first goal. And second one is operate maintain and rehabilitate facilities safely, reliably, efficiently to protect the public investment. So, the this is the second goal. And third one is enhance the organizational effectiveness of the water

resources coordination system promote capacity building and like a people participation So, these are some of the important overall goals as far as any watershed management planning is concerned, say strategic planning of watershed management is concerned.

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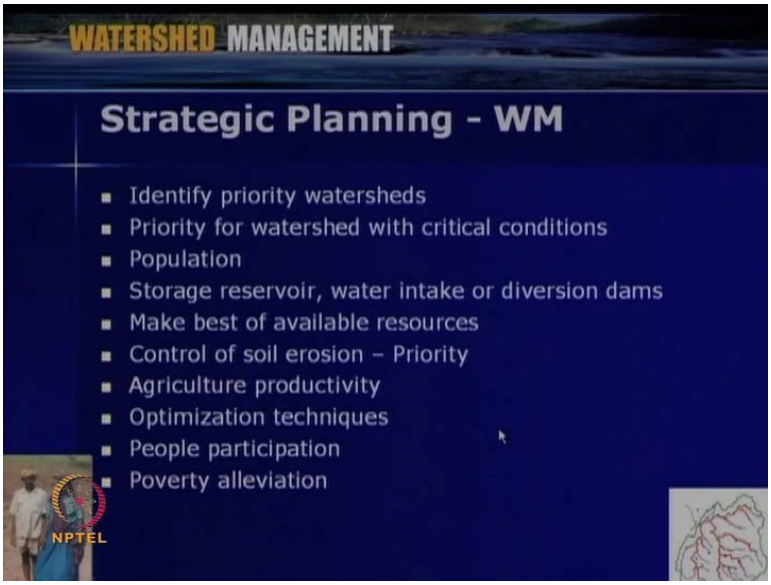

So, now with this say, goals, so we can say depending upon the say if you consider particular state or particular district or particular region, we can study the various issues for the particular region, and then we can go for strategic planning as far as watershed management is concerned. So, as part of strategic planning in watershed management, so first we can identify the priority of the watershed priority of the watershed. So, if there are so many watersheds for the region, then we can prioritize which watershed we have to do first intervention like that. Then priority for watershed with critical conditions - so, we can study the watershed whichever is which one is say deteriorated or which watershed was more problem, so that way we can prioritize. And then we can see the population of that region, so and their economical status, and then we can intervene.

And then storage says as far as the water issues are concerned for that particular region. So, on watershed basis, we can go for strategic planning, as far as reservoir development, water intake or diversion dams or water harvesting techniques. So, and then as far as various resources are concerned we can make best of the available resources for that particular area. Then say another important issue will be soil erosion; so say as we

discussed earlier say the soil erosion reduces the fertility of the area. So, we have to control the soil erosion, so we can go for conservation of the soil.

Then agriculture productivity, say if the productivity is very low, how we can improve it; then say what kind of say some particular area, say the using the optimal water use or optimal agriculture practices, how we can improve the income of the people. And in all this in strategic planning, we can take the people participation, and then we can just take hold analysis, and then we can take their opinion also. So in all this, our main aim will be poverty alleviation as far as the particular area is concerned.

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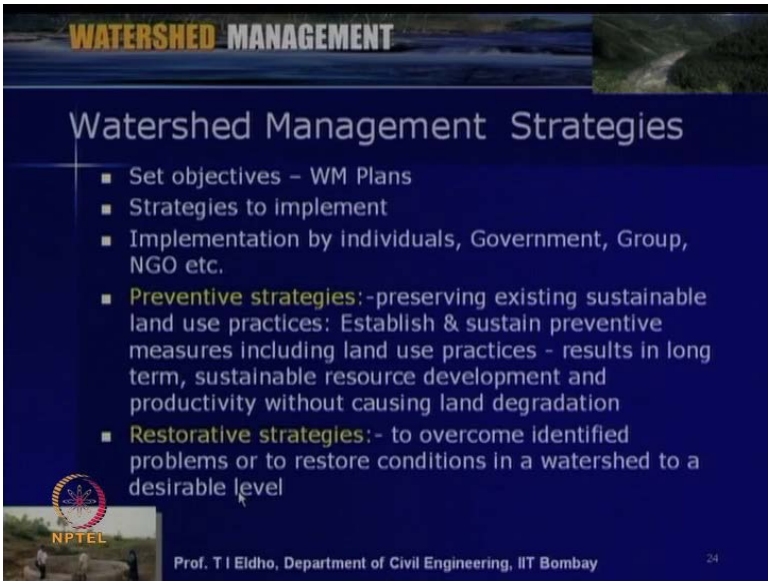

So now, say as far as watershed management strategies are concerned. So, as we seen the as we seen the previous slide, the strategic plans we can say, we can prioritize and then make the plans. So, first we can set the objectives, then we can choose the strategies to implement, then implantation can be by individuals, government or various groups or NGO‘s. So, as we discussed earlier the strategies can be either preventive strategies or restorative strategies. So, preventive strategies means, preserving the existing sustainable land use practices. So, and then establish and sustain preventive measures including land use practices; and then restorative strategies means, to overcome identified problems or to restore conditions in a watershed to a desirable level. So, preventive strategies we do it to, so that the watershed is not deteriorated as far as the resources are concerned; then

restorative strategies we identify say particular problems, and then go for to improve that problem.

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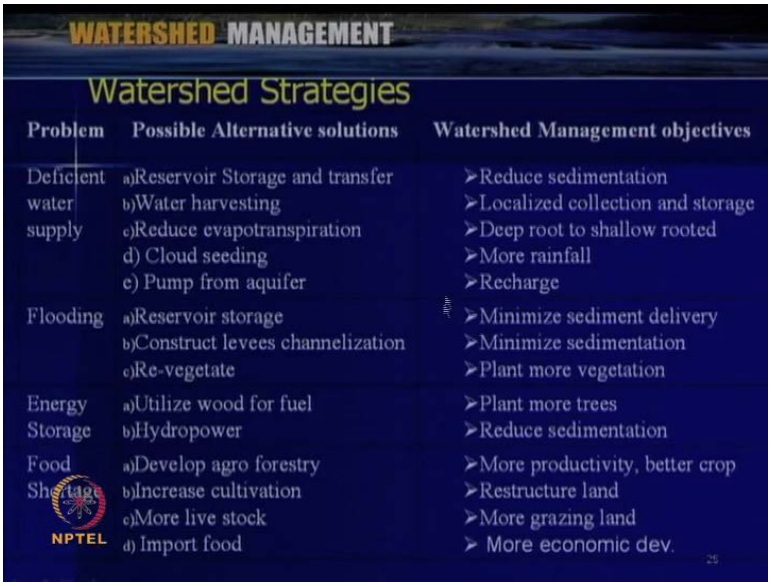

So, now depending upon the say area, depending upon the problem, depending upon the watershed, so we can identify the problems, and then we can look into possible alternative solutions, and then say we can look into the objectives as far as watershed management is concerned. So, here various problems are listed and corresponding possible alternative solutions are also listed, and then what will be the corresponding objectives; say for example, if the watershed is concerned deficient water supply is there.

Then we can go for reservoir storage and transfer, so effectively, we have to look reduce the sedimentation, then we can go for water harvesting. So, this can be improved this can improve localized collection and storage. Then we can reduce the evapotranspiration that may lead to say we have to go for deep root shallow rooted plants, then say for example, when some region, we can go for cloud seeding that may give more rainfall; and then some regions depending upon the ground water availability, we can pump from aquifer; and then obviously, we have the watershed management is concerned, we have to go for recharge.

So, if there are the problem is related to flooding, then we have to see that like reservoir storage, then revegetation, then construct levees etcetera. Then corresponding minimize

sedimentation, then plant more vegetation. So, similarly energy storage is concerned utilize wood for fuel, then hydropower, then food shortage is concerned develop agro forestry increase cultivation. So, like that depending upon the area, depending upon the strategic plans, we can go to deal with a particular problem, we can choose alternative solutions, and then depending upon the area we can go for that.

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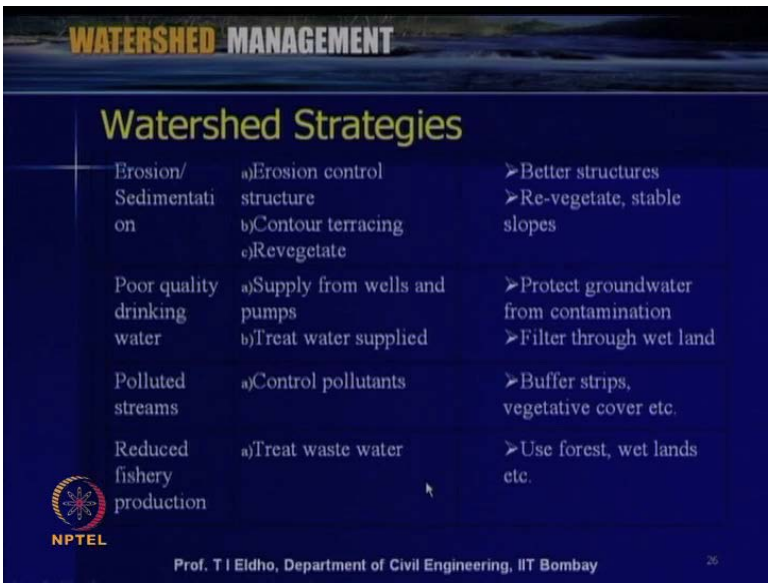

So, similarly erosion or sedimentation, we can go for erosion control. So, that we can construct various structures, then poor quality of drinking water we can treat water supplied, then polluted stream we can control the pollutants. Then reduced fisheries production, we can treat a waste water. So, like that, various aspects are possible.

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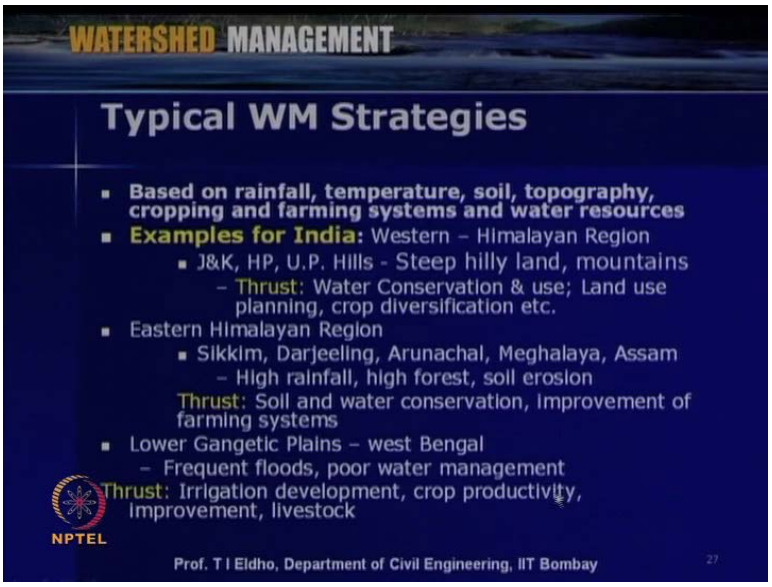

So now, as far as the typical watershed management strategies are concerned. So, this depends upon the area, this depends upon the resources available, and this depend upon the various issues, various problems for the particular region. Say for example, here say the typical watershed management strategies possible, say it is based on rainfall, temperature, soil topography, cropping and farming systems. So, say for example, India is concerned. So, if you take the case of India. So, if you consider western Himalayan region like Jammu Kashmir, Uttar Pradesh, Himachal Pradesh, etcetera. So, thrust will be water conservation and use, so that we can go for land use planning, crop diversification etcetera. Then if you consider eastern Himalayan regions like Sikkim Darjeeling etcetera, the thrust will be soil and water conservation, so that we can improve the farming systems. And then lower gangetic planes are concerned, the issues are frequent floods, poor water management; we can go for irrigation development crop productivity, improvement of livestock etcetera.

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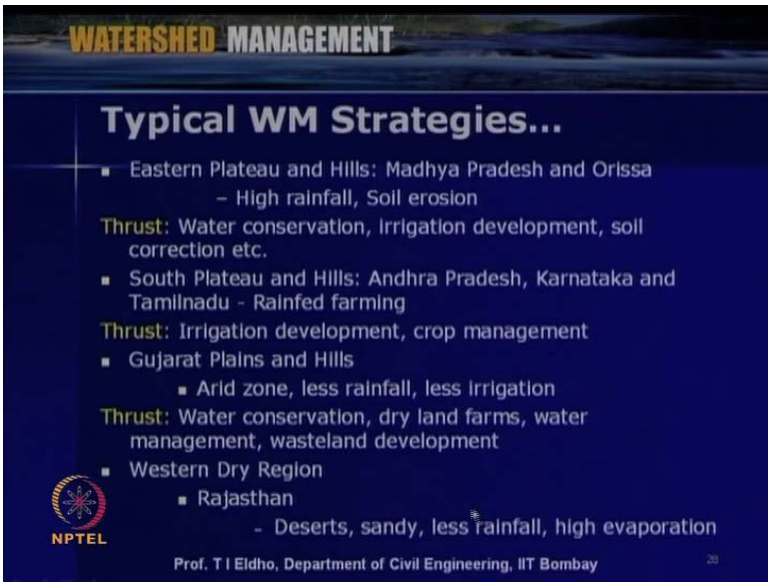

So, then eastern plateau hills like Madhya Pradesh is concerned, we have to go for water conservation. Then south plateau hills are concerned we have to go for rain fed farming, so the thrust will be irrigation development, crop management. Then Gujarat region is concerned, it is arid zone less rainfall, so we have to go for water conservation, dry land farms, water management etcetera. So, western dry region like Rajasthan, then we have to go for say here we have to go for like today, what we discussed for dry dry land management, so water harvesting and other related issues.

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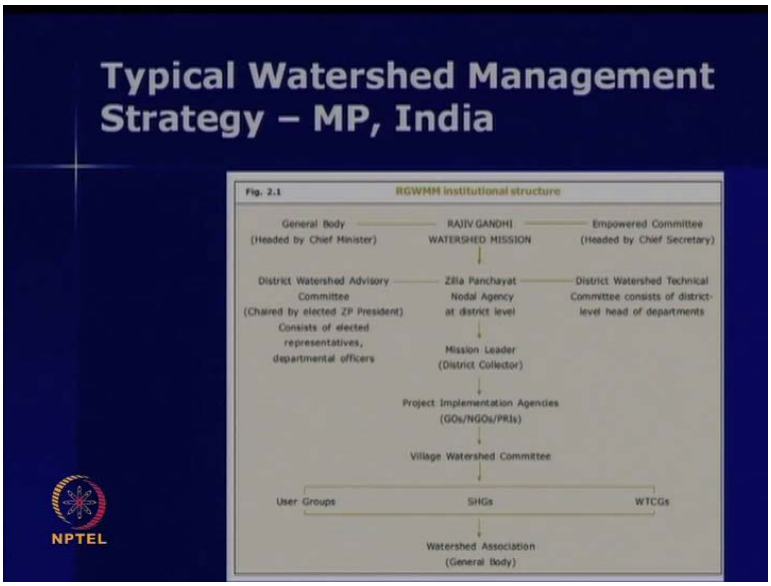

So, now say for example, if you consider typical watershed management strategy is a under the amble of Rajiv Gandhi watershed machine. So, the government of India is implemented many schemes in various states say for example, in Madhya Pradesh, this is a mission under the nodal agency at district level, where a mission leader will be district collector; and then the various inputs from district watershed technical committees; and then district watershed advisory committees are considered; and then the project implementation will be by government agency or non government agencies; and then it will be the implementation projects can be through village watershed committees like user group; and then water related user group, land related user group, so that the there will be a watershed association will be there, who controls overall project implementation. So, that way the watershed strategies we can say develop, and then implement.

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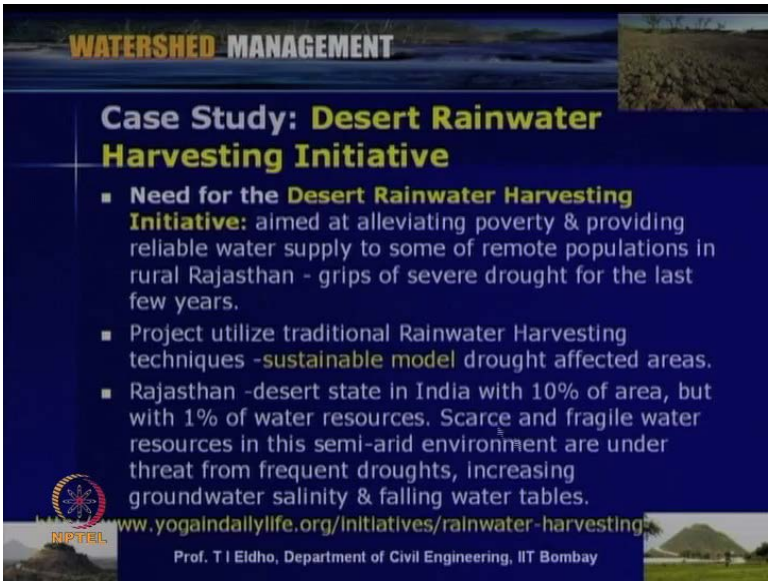

So, before closings today's lecture, let us briefly discuss a case study as far as the watershed management in arid region is concerned. The case study is from desert rain water harvesting initiative from western Rajasthan. So, here the main issue was say water availability. So, this is a sustainable model for drought affected areas. So, this is mainly implemented in a western Rajasthan. So, here the NGO, they are concentrating upon rainwater harvesting measures in the particular area is concerned.

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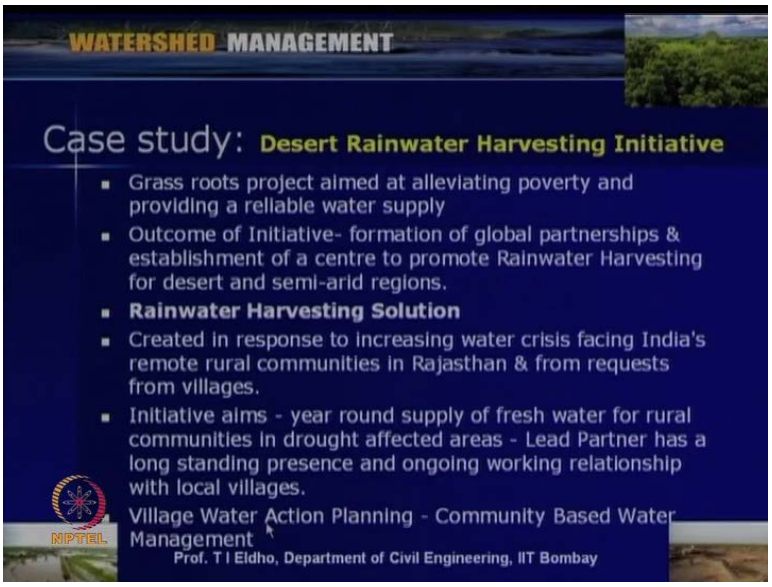

So, the grass roots projects are aimed at alleviating poverty and providing a reliable water supply. Outcome of initiative involve formation of global partnerships, establishment of a centre to promote rainwater harvesting. So, then rainwater harvesting solution, so that is the main thing, you can see that say for example, one particular village, so here the rainwater harvestings were constructed.

And then after few years, you can see that there good storage of water, and the area the phase of that area is totally changed. So, this has been implemented by the NGO's with the people participation. So, these decide rainwater harvesting initiative created in response to increasing water crisis facing in this Rajasthan region. So, initiative aims year round supply of fresh water for rural communities in drought affected areas, and lead partner has a long standing presence in the area, and village water action planning committee they are managing and developing the system with the help of the organ the NGO.

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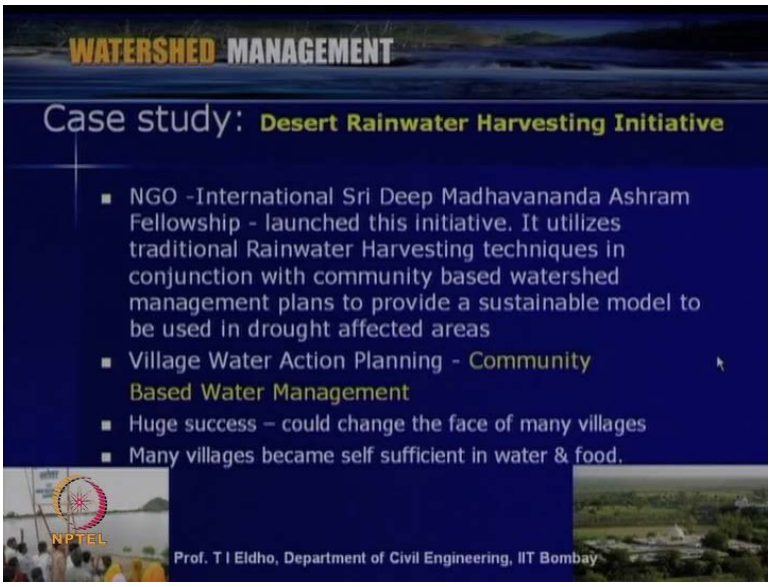

The NGO is called international Sri Deep Mahavandhana Ashram fellowship. So, they launched this initiative. So, this NGO is utilize the traditional rain water harvesting techniques in the area, in conjunction with community based watershed management plans to provide sustainable model to be used in drought affected areas. So, say village water action planning committee called community based water management system is generated; and after implementing say this project so-called desert rainwater harvesting initiative say by considering many of the rainwater harvesting techniques, what we discussed today.

So, it is absolutely many of the village say there is sufficient water is available, and many village become self sufficient in water and food. So, this project has become a huge success in a many of the villages, and then this has changed the phase of the phase of many villages, and now still this program is going on in many of the villages. So, you can see that the rain water harvesting initiative for the arid regions say once it is implemented with the help of the people participation the this, there is huge success and then it has become a sustainable watershed management project.

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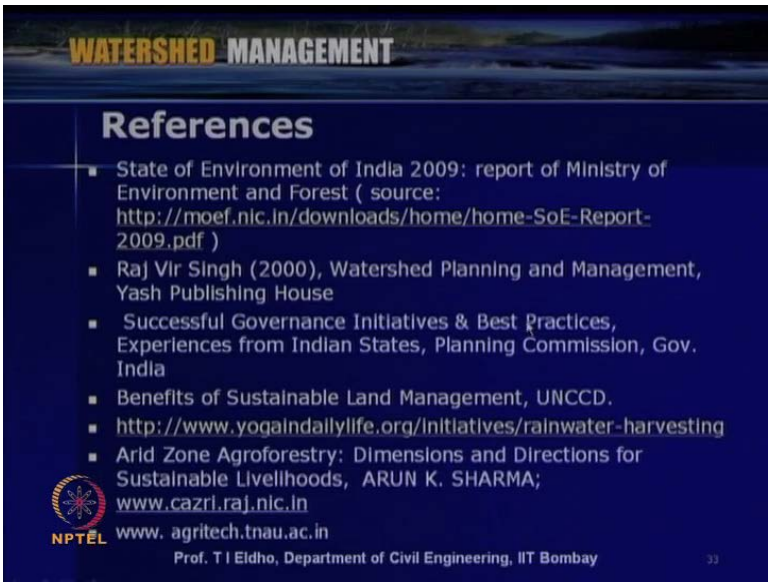

So, some of the important references used in today's lecture lecture are listed here.

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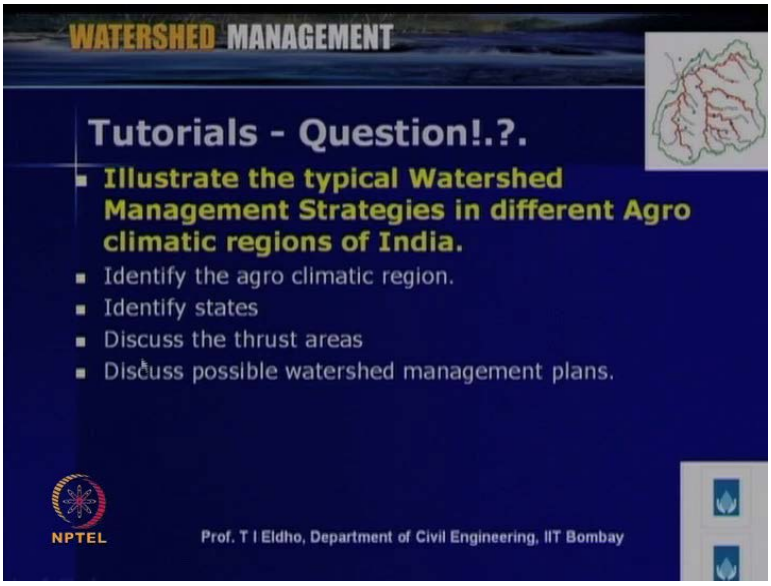

So, before closing, say one tutorial question related to today's lecture; illustrate the typical watershed management strategies in different agro climatic regions of India. So, we have seen different agro climatic regions of India in earlier lecture also. So, we can identify the depending upon the various conditions the agro climatic region; and then we can identify the states; and then we can say look into the thrust areas; and discuss the possible watershed management plans for that particular region is concerned.

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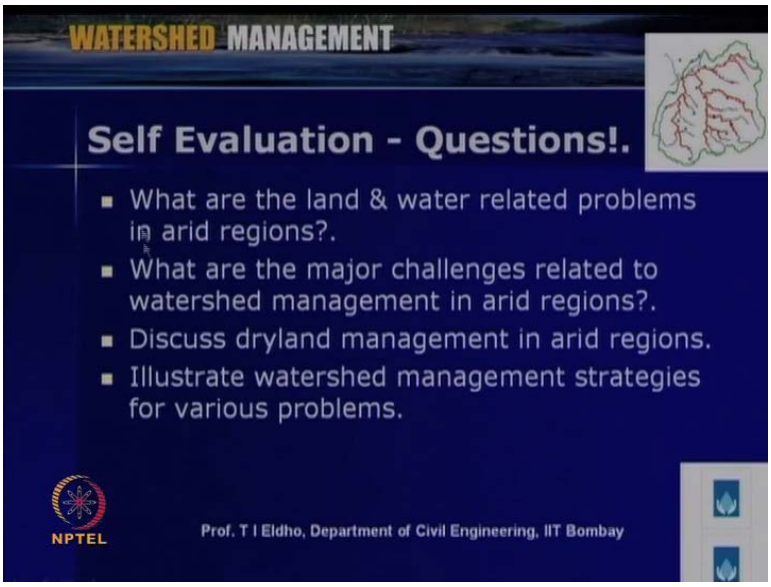

So, as self evaluation questions, some four questions are listed here; what are the land and water related problems in arid regions; what are the major challenges related to watershed management in arid regions; discuss dry land management in arid regions; illustrate watershed management strategies for various problems; so, these all discussed in today's lecture.

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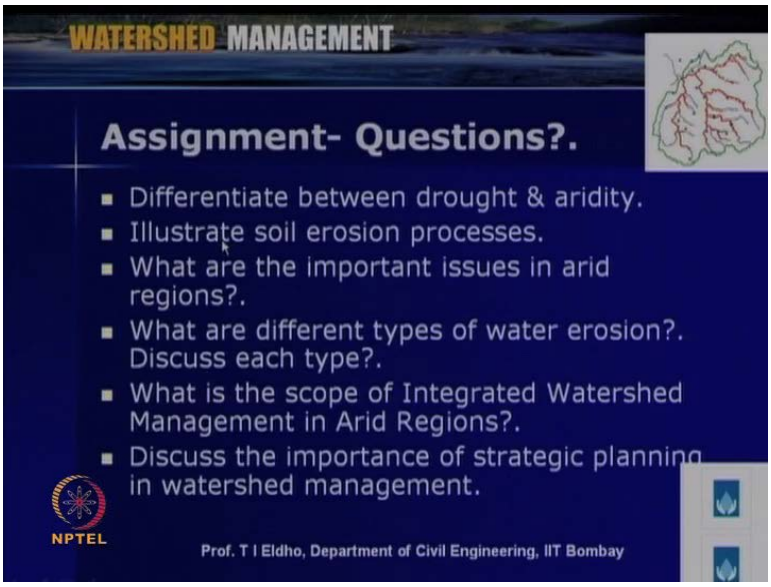

And some of the assignment questions like differentiate between drought and aridity; illustrate soil erosion processes; what are the important issues in arid regions; what are

different types of water erosion, discuss each type; what is the scope of integrated watershed management in arid regions; discuss the importance of strategic planning in watershed management; so this question's related answers already available in this, in today's lecture.

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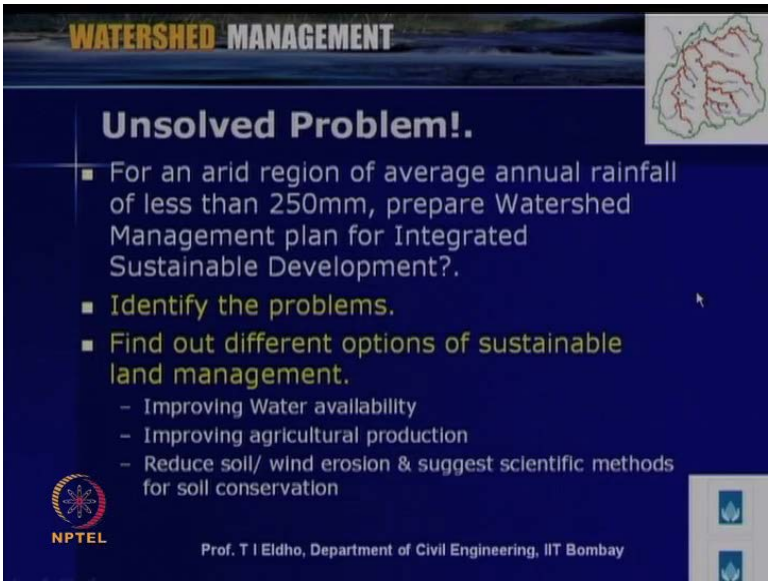

So finally, an unsolved problem for an arid region of annual rainfall of less than 250 mm, you can take a particular case study; and prepare watershed management plan for integrated sustainable development. So, as we discussed you can identify the various problem for the considered area, then we can find out different options of sustainable land management, so that so we can improve the water availability, then we can improve the agricultural productions. And then we can look into various issues to reduce soil or wind erosions, and then we can we can suggest some scientific methods for soil conservation for the particular area considered. So, with this, this module two is over. So, say today we discussed mainly on the watershed management practices in arid and semi-arid regions and then the various strategies as far as watershed management is concerned. Thank you.