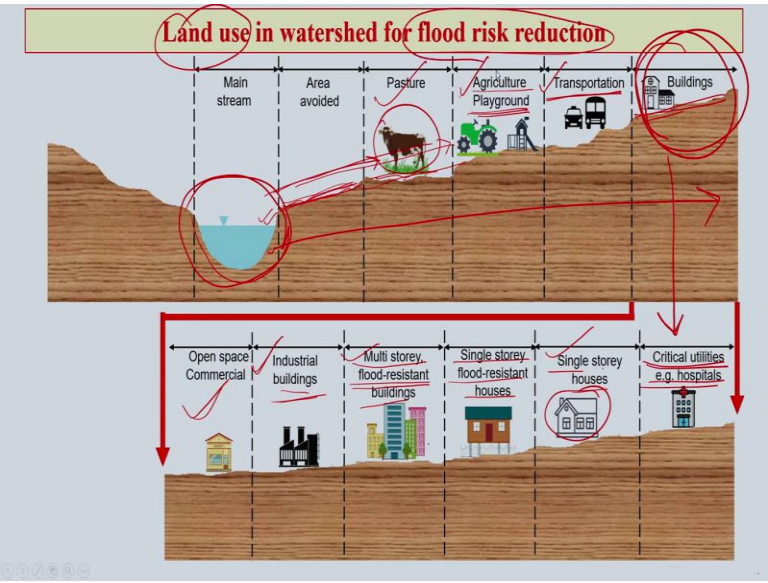
Natural Resources Management (NRM)
Professor. Sudip Mitra, PhD
Centre for Disaster Management & Recharge (CDMR)
Head, School of Agro & Rural Technology (SART)
Discipline - Agriculture Engineering
Indian Institute of Technology, Guwahati, Assam, India
Week - 04
Lecture - 27
Landuse Management for Flood Risk Reduction

Now, next is land use in watershed for flood risk reduction. Now, we were just discussing about that how different measures that we can take for flood control, we discussed various approaches.

(Refer Slide Time: 00:47)



Now, land use also plays an important role in flood risk reduction. Now, if you see in this figure, so, this is your water area; mainstream. Now, ideally how the land use should be placed. Now, immediately after this mainstream water area ideally, we should have almost nothing here, this particular the first closest area to the mainstream, then next we can have pasture.

Now, this pasture will of course have dual role; it can also restrict the soil erosion, it can also reduce the speed of flood water intrusion towards the land area. And also, livestock can also be grazed. After pasture we can have agriculture area and as well as playgrounds for community. Now, this is the area where you also need to ensure the supply of water. And at the same time,

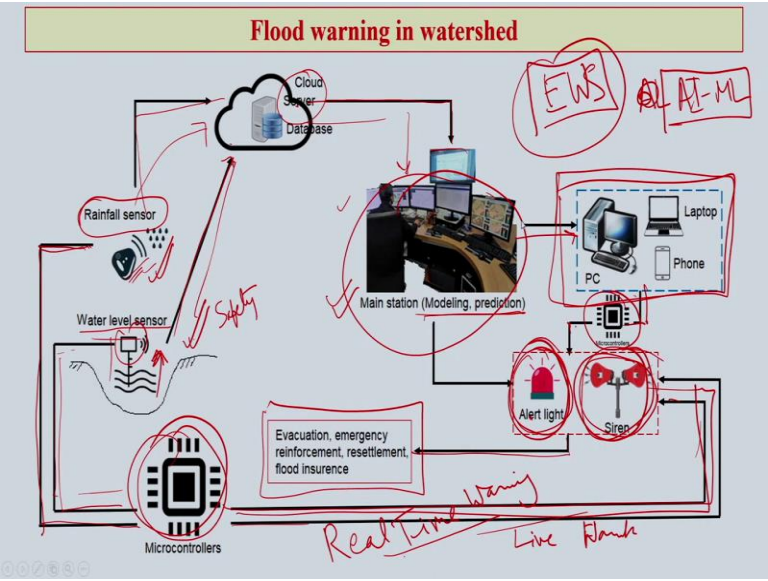
you should be also a little bit sure about that frequent intrusion of water from the river or from sea line will not come inside the agricultural land.

After agricultural land ideally, we should have transportation roads, and finally, your building starts, any kind of building office, school. And you can see that in below picture here. So, what are the different kinds of buildings and how it should be placed? Now, first is commercial group, commercial type of building should be created in open space. Then we can have industrial buildings. I am talking about this type of building within this particular land use for building, which should be farthest from the mainstream. After industrial building, we can have multistorey flood resistant building, which could be building like flats for people to reside there; it could have office space also there.

So, multi-storey building flood resistant building you can have next to the industrial building. Little bit more inside you can have single-storey for resistance houses, and then you can have single-storey houses. Because this is now is a bit far from the mainstream, so the chances of floodwater intrusion are relatively less.

Finally, you have critical utilities like hospital because we need to ensure that such critical facilities must be far away from the chances of any kind of flood water intrusion. So, this is how you choose land use and accordingly you place them to reduce any kind of risks that may occur from flood.

(Refer Slide Time: 03:53)



Now, early warning system; EWS, early warning system is a very, very important aspect for anything, whether it is flood, drought, cyclone, anything, any kind of natural calamity that you can think of. Early warning system is very critical for saving life and other resources. Now, uses of advance technologies, artificial intelligence, machine languages, these are the advanced technologies, which these days are being utilized for developing efficient early warning system.

Now, for flood how it work. Now, you have some sensor which starts from in a very basic steps, you have some sensor; rainfall sensor, which can detect and can send the signal to the server which you have in cloud and also the database are created. Apart from rainfall sensor you can have also water level sensor, means this is the sensor, so if your water level rises beyond a certain limit, it will automatically send a signal into the server and that data will be stored there.

From the server the information will go to the main station where a person or team of person will continuously monitoring that and then they will utilize those sensor through some modeling and then they will come up with early warning or prediction of an event. Now, this main station has all the kind of machines that you need and these machines are largely regulated by several kind of microcontrollers and these microcontrollers will provide some kind of warning either through light system or through sound system.

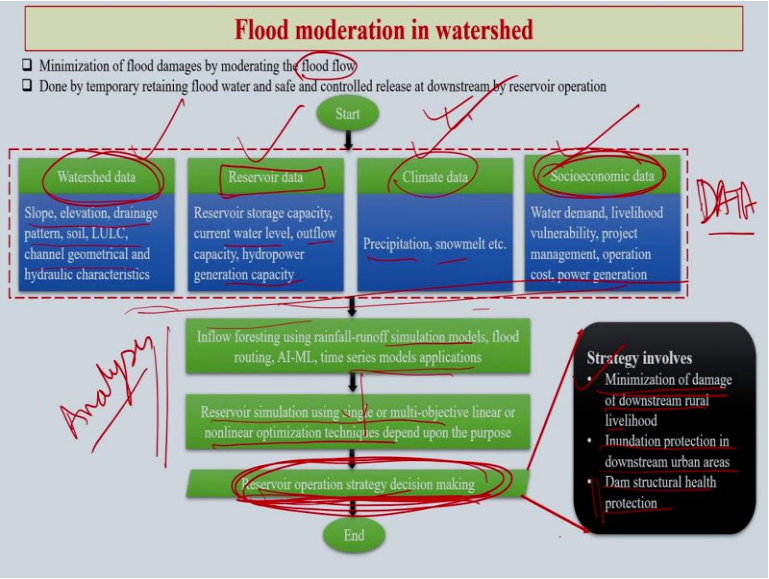
Now, the information which generated from the field through sensor, now, these information straightaway go to the server come to the main station, processed here. The information goes to the systems, from the systems the message goes to some microcontrollers and then they translate it into either light early warning system or sound based early warning system.

So, when it comes, this information goes to the people to various stakeholders, state disaster management authorities, people who are involved with evacuation, so, they get alerted and then accordingly the action is being taken.

Now, here is another way that from the sensor as I said the information can directly go to the server, but the other part from both the sensor say rainfall sensor and water level sensor, it can also go through sets of microcontrollers straight away to the warning system.So, this warning would be kind of what you call live early warning system or live warning system or you can say real time warning. So, as soon as there is a rainfall and the water level goes beyond the safety level, immediately through some sets of microcontrollers, it goes to the warning system; light or

siren. So, that would be your kind of real time warning, the other part I have already explained, which comes in the form of early warning, utilizing some modeling system or use of AI-ML.

(Refer Slide Time: 07:57)



Now, suppose, you get the kind of information or warning or you know that that could be flood situation, how you can moderate that kind of situation in an watershed, that is very important. Now, minimization of flood damages by moderating the flow of flood is one aspect of flood moderation in watershed and these moderation of flood in an watershed largely done by temporary retaining of flood water and through safe and controlled release towards the downstream.

So, these are the two main moderation ways that are being used for flood moderation in any watershed. How this process takes place? Suppose, you have a situation of flood, now, how the process of moderation will start? So, in watershed level you will have some data as I just mentioned in the previous slide, it could have in the cloud, or it could have in the server or in different manner. Now, watershed has certain information about slope, elevation, drainage, land use, hydraulic characteristics, etcetera. Then you have reservoir in that area, you have also information about the reservoir storage capacity, current water level, outflow capacity, hydropower generation capacity. You also have with you the climate data, which talks about precipitation, wind, etcetera.

Then you have socio-economic data, where you have the information about the water demand, the livelihood vulnerability, the project management system, operating cost, power generation, all these information you have under socio-economic data. Now, once you have these all data or information with you, then you using this rainfall and runoff data you go for simulation models, flood routing, you use AI-ML and different kinds of time series models applications to come up with some kind of anticipatory solutions.

Now, reservoir simulation using single or multi objective linear or nonlinear optimization techniques also are there, but they depend on your purpose. There are various option. So, which one to go for will be decided the purpose for which you are going to use that. Now, once you analyze all these data that you have and through these you run some model and come out with some kind of decision support system, then you get the reservoir operation strategy decision in the process. On the basis of this database, which you have with you and through certain advance analysis of those data, finally, you come up with a strategy. One can call it as Decision Support System DSS.

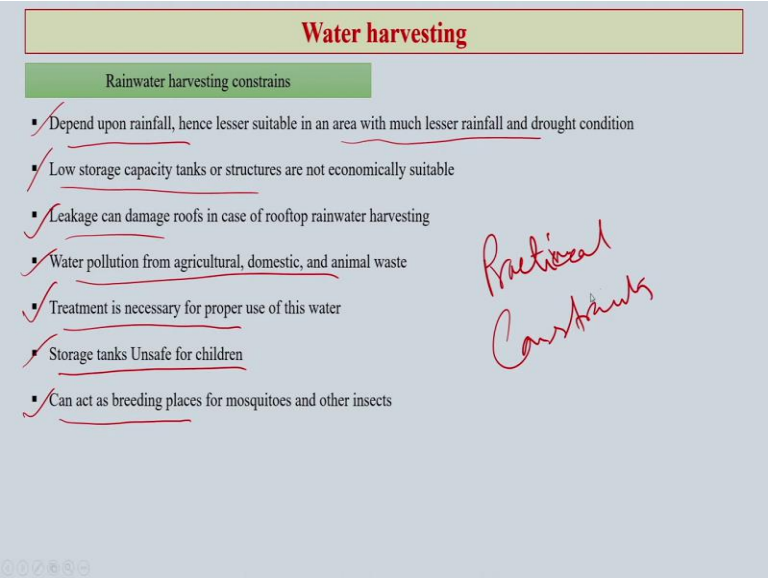
Now, what at this stage, the strategy or decision making stage what are involved in that particular process; minimization of damage of downstream for rural livelihood, because from upstream when you see the water level goes beyond safety limit, suddenly you have to decide to allow some water to go to the downstream, but that amount of water which you are going to allow to pass towards the downstream also depend on that the livelihood, the agricultural areas and other aspects which are located there in the downstream.

So, you have to consider the impact of releasing the water towards downstream beforehand. So, minimization of damage of downstream in the rural livelihood can also be decided to this kind of exercise which I just expressed, then inundation protection in downstream and urban areas. Often it happens that, it is not because of the rainfall, that the downstream area is getting inundated or flooded, but it gets because the water has been released from some dam or someplace where you have a reservoir.

So, that decision has to be taken considering upstream as well as downstream condition. Dam structural health protection is also another aspect, which taken care of in this process, when you make the decision.

So, coming back to this, that the entire flood moderation system, which is very important for any watershed? We start doing it with the help of the data that we already have, and these datas will go into different kinds of modeling systems and then they will analyze that, that information will go ultimately through some optimization exercises, to be sure that yes, what you are going to give the decision is almost error free, because any decision taken there could affect either upstream or downstream people, infrastructure, resources. So, these are the aspects that we should keep in mind.

(Refer Slide Time: 13:36)



I earlier talked about water harvesting issues, I also discussed about roof water harvesting, and why it is important even in area where good amount of rainfall takes place, those things I have discussed. Now, few point I just thought of sharing with you is that water harvesting is good, we know that, but there are certain constraints that that practitioners or administrators or community when they go on the field to do it, they may face this constraint and they are like rainfall.

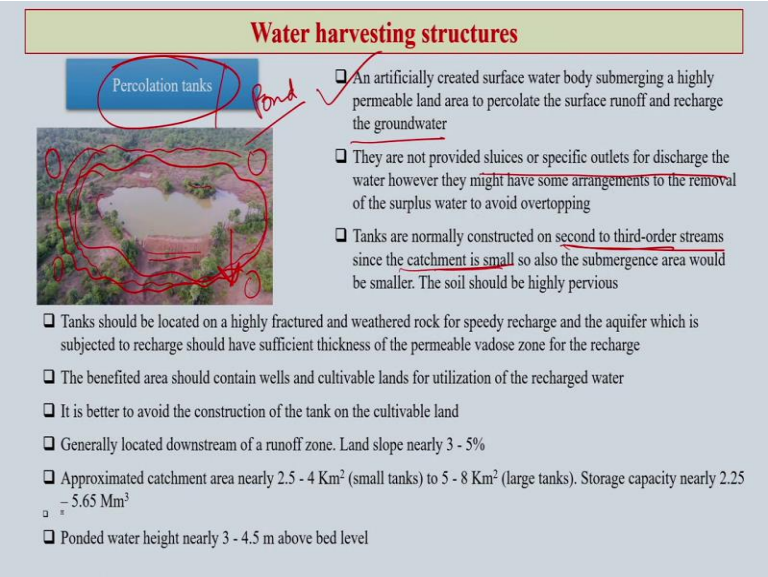
So, it largely depends on the amount and frequency of the rainfall. So, water harvesting generally is not much suitable in an area with much lesser rainfall or drought condition, we know that. Second, low storage capacity tanks or structures; they are not economically suitable for water harvesting. Third, leakage issue; if you have leakage issue then your entire effort investment energy for having water harvesting could be a failure.

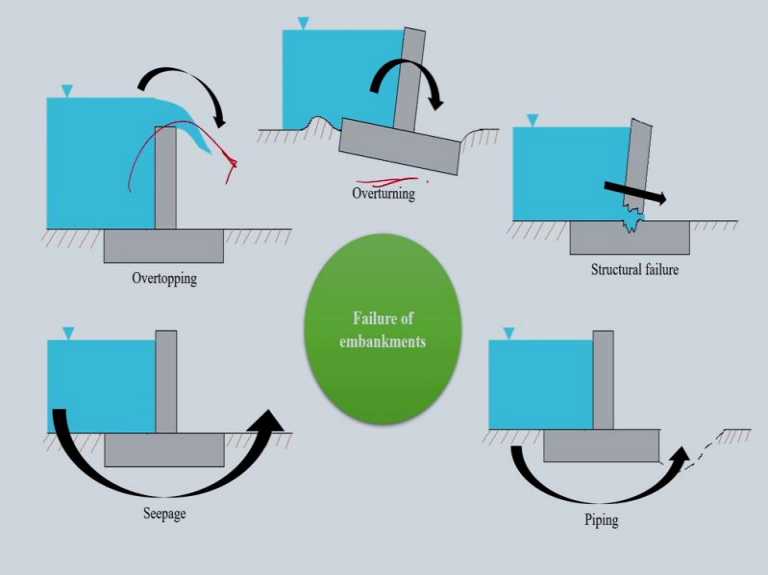
Water pollution; another aspect you have suppose successfully done the water harvesting, stored it, but the water that you have stored if it is already contaminated, then it is of no use. So, it is important to see the water pollution level and surrounding agricultural, domestic and other waste nearby to that area. Treatment is necessary for proper use of the water that you have harvested.

Sometimes storage tank in village areas could be unsafe for children. I am talking these about our Indian condition system in the rural area, because still there are a lot of cases reported that small kids, they often fall down in some kind of deep hole or some kind of structure which are kept for some other purposes. So, this is again one very practical issue or constraint then often you might face it in case of water harvesting.

This can also act as breeding places for mosquitoes and other insects. These days when you have various kinds of like dengue, etcetera, so, clear water is also we know that is a very suitable building place for dengue mosquitoes. So, these are few very practical constraints or challenges that we have in our hand that we need to take care of while we go for water harvesting.

(Refer Slide Time: 16:29)





Now, in case of water harvesting, you will find that at the rural level or at the village community level, one of the most common water harvesting structure that you can see is percolation tanks, or in some cases people call percolation pond. Now, this is artificially created surface water body which is highly permeable, and this should allow the water to percolate down below so that it can recharge the groundwater. That is the main purpose of percolation pond.

Now, this percolation pond, they are not provided with sluices or specific kinds of outlets for discharge of the water. However, these percolation tanks sometime could have some kind of arrangements for the removal of the excess surplus water to avoid just overtopping. Remember that we have discussed about toppling down of system in case of kind of flood situation. So, this is what is talking about, that overtopping can also takes place, overturning can also takes place. So, these we have to also keep in mind.

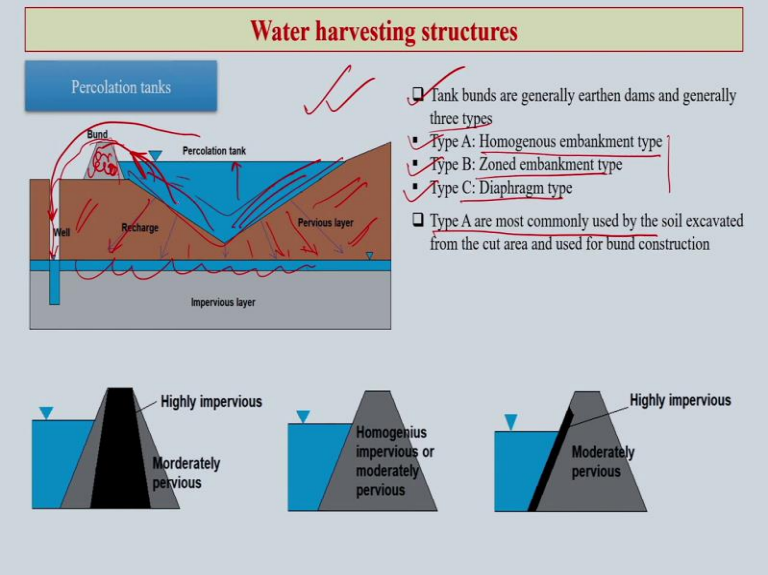
Now, tanks or ponds, percolation tanks or percolation ponds, normally constructed on second or third waters streams, why, because the catchment is generally small. So, also the submergence area would be smaller, relatively smaller. The soil needs to be highly percolating in nature, because whatever water which is stored in the percolation pond has to go down has to percolate so that it can basically recharge the groundwater because that is the major purpose of having the percolation pond for water harvesting.

Tanks or these ponds should be located on a highly fractured and whether rock again for speedy recharge of the aquifer, which mostly, gets recharged through this percolating water. So, the

benefitted area the surrounding area of this percolation pond should contain wells and cultivable lands for utilization of these recharge water. So, if you have a percolation pond here, ideally you should have kind of a recharge well here in these areas.

And of course, these percolation ponds should be surrounded by agricultural land, because these areas, groundwater is supposed to be already recharged by the presence of this percolation pond. So, the pond water height, in general, are somewhere in between 3 to 4.5 meter above the bed level, which is an ideal kind of height for such kind of percolation pond.

(Refer Slide Time: 19:40)



So, this is a very simple water harvesting structures, but has very good effect on recharging groundwater. So, how actually, it works; percolation tanks. So, as you see that this is the picture it can explain you about the technicalities of percolation tank. So, this is the water body the tank you have, you can have a small bund here in case this water level rises and should not go there.

But even if after some time because of excess rainfall, if the water crossed this bund, it can come inside this well. And again, it can recharge the groundwater. Obviously, this percolation tank which is already you have created they will directly recharge your groundwater as you see these arrows, so they will already going to recharge.

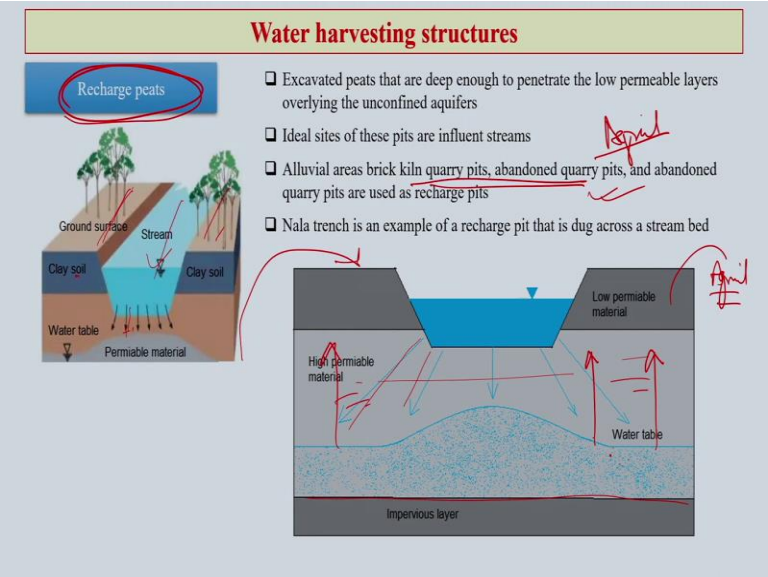
And in case of excess water if they pass the band, they will go inside the well and again they will recharge the groundwater. Again, these areas largely should be pervious layer means water should be allowed to percolate so that it can recharge this groundwater. So, in case of tanks,

bunds are generally made of earthen dams and generally three types, which we see in conditions like India and Indian subcontinent.

Type A, which is homogeneous embankment type, we have discussed about embankment earlier. Type B, zoned embankment type, and the third type, Type C is a diaphragm type. So, these are the three types of earthen dams that we normally see in case of percolation tanks like structure for water harvesting.

Among these three, you will find that type A are the most commonly used earthen dam which is normally created by excavating. This soil you deposit here and you create a earthen kind of dam or bund. So, even the soil which is comes out of these excavations are used for making the earthen bund or dam. So, this is brief is the percolation tank inside detail.

(Refer Slide Time: 22:13)



The second type of in our water harvesting structure at the community level comes recharge peats. Now, recharge peats are made through excavations which are deep enough to penetrate even the low permeable layers overlying the unconfined aquifers. So, before the aquifers even if you have a low permeable layer, this recharge peats will allow you to take that water even into aquifer crossing these semi permeable or less permeable layers.

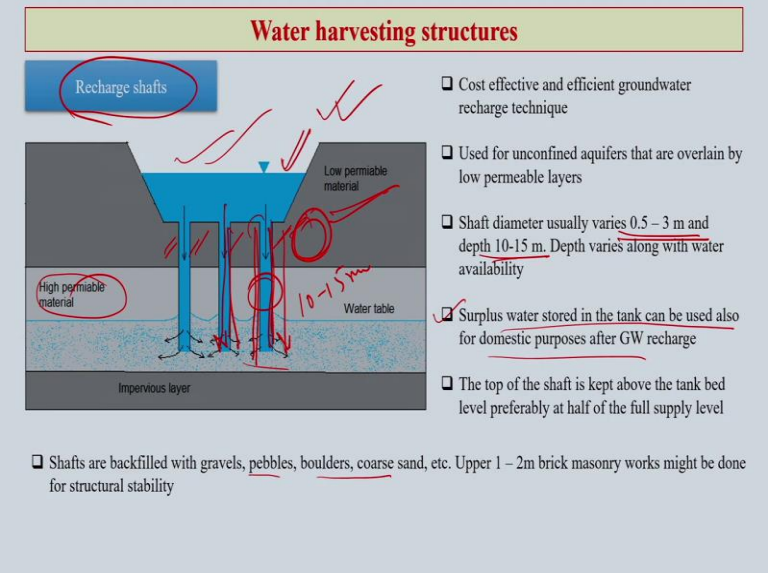
And these recharge peats are ideal sites which influence those streams, which you are having in and around that particular area. Alluvial soils or alluvial areas, you will find in brick kiln, abandoned quarry pits and various kinds of things, mostly in the alluvial areas. The reason is that

that soil is very good for having this kind of small industry, but we all know that these are the things which these days coming in fact in between agricultural land. So, that creates a lot of problem with not only with polluting the soil but also the surrounding water bodies.

Now, how we have created this kind of recharge peats. Now, you see that this is the stream you have any stream inside an area and then these are the ground surface you have plants, clay soils supposing the both side, then water goes down below the water table.

Now, come here this picture, which will clearly explain how this thing is happening in case of recharge peats. Now, we have, suppose high permeable material here because, I said that this is important for groundwater to be recharged. So, water comes through and straightaway goes to the water table. And then you have impervious layer and these water tables slowly it goes up and utilizing these recharge water table you can have your cropping system agriculture or other activity utilizing this water.

(Refer Slide Time: 24:41)



So, next comes the recharge shafts, now as you see in this picture is a little different than the previous two. Here, again, we have the water body or the stream here, here you allow through some channels the water to go into the water table directly and here you can have in between also the high permeable material here and low permeable material here.

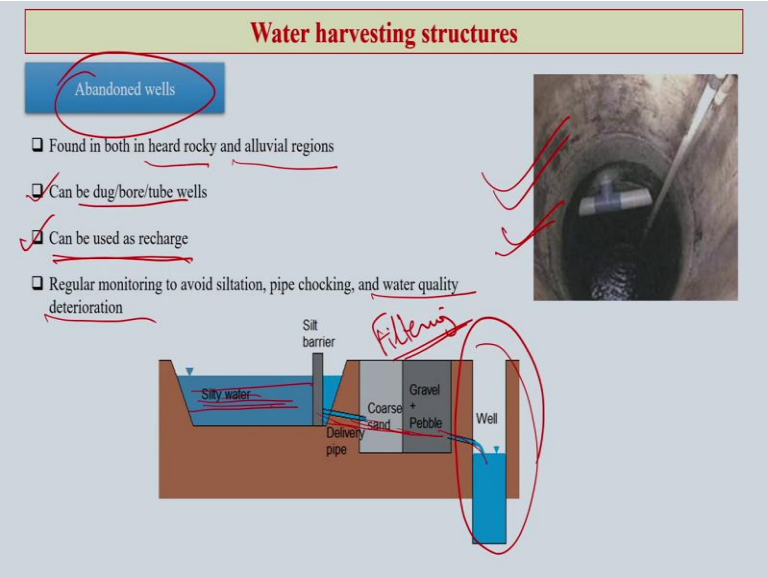
So, to bypass this low permeable material, you use this kind of channel to allow the water straightaway to go into the water table. It is cost effective and also efficient for groundwater

recharge purposes. Normally these recharge shafts are used for unconfined aquifers that are overlaid by low permeable layers as you see here. Shaft diameter, varies between 0.5 to 3 meter and depth 10 to 15 meter.

So, depth can vary along with the water availability. So, your amount of water available there on the stream will decide the depth of your shaft. Now, the surplus water which is stored in the tank can be used also for various domestic purposes and groundwater recharge.

As you see here in this picture, the top of the shaft is kept up the tank bed level preferably say around half of the full supply level. So, that is where you will keep your top of the shaft. So, shafts are again backfield with gravels, with gravels, pebbles, boulders, core sands. And the top 1 to 2 meter is normally brick missionary works might be done for stability of the shaft, just to give a little bit more stability. So, this is the way the recharge shafts are being constructed and utilized for water harvesting purposes.

(Refer Slide Time: 26:54)

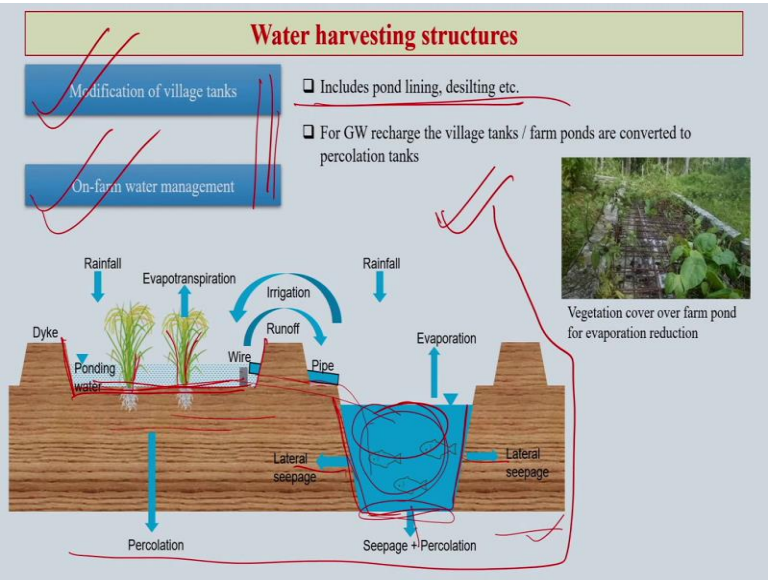


Next comes abandoned wells. Now, these are very common in our Indian villages and rural areas. You will find this kind of abandoned wells many places across our rural areas and villages. Found in both in case of hard rocky area and also alluvial regions. These can be dug, or bore as tube wells we have also in the villages. So, same kind of thing that can be used as well for water recharging.

This can also be used as groundwater recharge, which you have here in this picture, but one important aspect is that with these abandoned wells, the regular monitoring is required. Otherwise, what will happen that these abandoned walls can have siltation; it also can have choking of the pipes. Most importantly, the water quality may get deteriorate, pollutions can also impact this water because as I said that if your water whatever you have harvested after a lot of effort and energy and resources, if you find those waters are polluted in nature, the entire effort of yours goes totally what you call waste for that purpose. So, regular monitoring is very, very important for this purpose. So, we can have various kind of situation for this kind of abandoned well.

And these abandoned well sometime what happens is that if you have the stream and the water nearby the source of water nearby then you can have some delivery pipes from the water stream, it can pass through core stand and gravel and pebble and then finally can go into the well. So, this is the way a kind of small filtering of the water that has been harvested can takes place and we can avoid the chances of contamination of harvested water.

(Refer Slide Time: 29:11)



Modification of a village tanks and on-farm water management. these are again very common in our Indian condition. This modification of village tanks, on-farm water management normally carried out through lining of pond, desilting of pond, then tank and farm ponds, percolation

ponds which are used for groundwater recharges. So, what happens is that this picture will explain you in detail about these type of water harvesting structures.

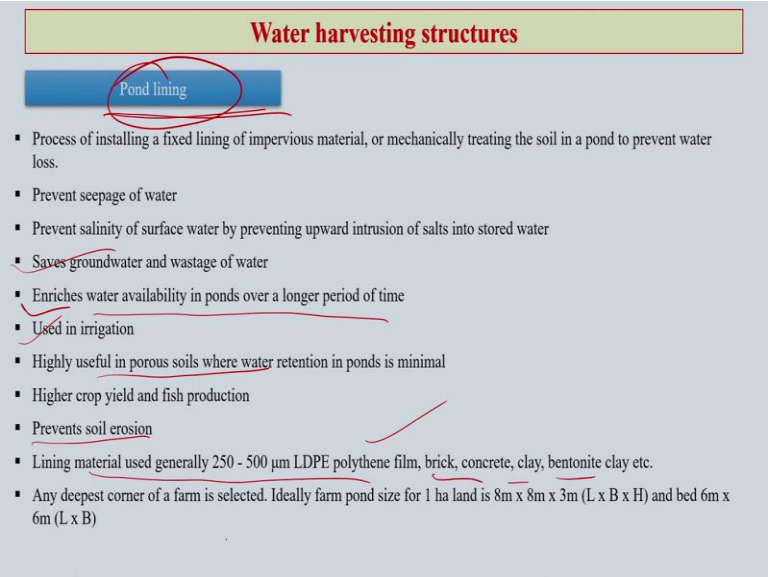
Suppose in an area you have a pond area, where you have water, rainwater also gets stored, you can grow certain kinds of plant species which love flooding condition like the rice. So, apart from growing the crops in that flooded area, that water which is stored in the pond area, you can protect them through some dyke system, also you can have some piping system from this water body; take the water into a seepage or percolation pond.

Now, once this water comes here, you can use it for aquatic lives, fish and etcetera, some other uses. So, once it comes into percolation pond, then that it is going to recharge your groundwater both way it can go vertically down and also horizontally on both sides. So, what happens is that this on-farm management of water harvesting is very sustainable in nature and it could be very useful for overall development of the water resources in any rural area.

The reason is that in one hand, you are able to get a crop which can withstand flood water or flooded condition. On the other side, you are also having your groundwater recharged. So, this kind of situation can be created very easily in any Indian rural area or villages. And sometimes you will find that some of the small ponds or tanks are often having kind of vegetation cover or aquatic life.

So, you can have livelihood also from utilizing that the water the rainwater which is stored in the pond or in the percolation pond. So, overall this can be a kind of a win-win situation. In one hand, you store you harvest the rainwater; on the other hand, you generate income utilizing the water that is stored apart from recharging your groundwater for future agricultural practices, irrigation.

(Refer Slide Time: 32:12)



So, this is how you see that different water harvesting structures it helps. Pond lining is also important in case of water harvesting structures in the rural area. So, the lining of pond is critical to avoid the erosion of the soil and also you allow the water to get stored in that particular pond for a longer time.

Now, it stops or reduces the seepage of water the pond lining. It also prevents salinity of the surface water by preventing some upward intrusion of soils in the stored water that you have created in the area. It also saves groundwater and wastage of water, excessive water evapo-transpiration can also be regulated to some extent, it enriches the water availability into ponds for a longer period of time.

Normally, this water can be used for irrigation more efficiently if your ponds are having linings. Highly useful in case of porous soil, where water retention in ponds become a challenge. So, if you have pond lining, then you can allow the water to stay there in the pond otherwise it will pass very quickly from the storage tank. It prevents soil erosion. Lining material we use different kinds of lining materials, polythene film, brick, concrete, clay, bentonite clay, etcetera. I will show in the next slides a couple of examples of those.

(Refer Slide Time: 33:47)

Polyethylene lining, this looks like this, but if you ask me I would not go for polyethylene lining as the very first preference; neither I would go for concrete lining again as the first preference. So, what I will prefer at the village level is that clay lining for obvious reasons and then you can go also for brick lining. But if you need little larger amount of water storage, and if you need for a larger uses of irrigation or covering the larger area of agricultural practices, then you need concrete and polyethylene type of lining, because of course, they can allow the water to get stored for a much longer time, but clay lining and brick lining these two are the cheaper option and also sustainable in many ways.

(Refer Slide Time: 34:49)

These days many kinds of new materials are coming for water harvesting structures; geotextile, geosynthetics, these are some of the things which are coming increasingly in case of water harvesting structures. Anicut, we are already using in many cases in southern part and also in the western part. These are basically small water harvesting missionary dam which are normally constructed across a stream and the water is largely used for irrigation and also for drinking purposes.

In Rajasthan especially if you have been there, you will see that hundreds of years back the ruler of Rajasthan, the Kings, they used to have kind of water storage structures which they call baoli. Now, this is amazing to see that even hundreds of years back they had such kind of technology knowledge with them. These baolis could store water almost the entire dry season. So, they could utilize this water for many, many months when the outside weather is very harsh or completely dry baolis will have water there, which is stored from the very little that window of rain that they used to get. Baolis are kind of stepped wells for water harvesting. So, they make it stepwise as you see in this picture.

So, some of the water harvesting structures in the northern part of India often you will see they call it taanka. So, these are traditional again rainwater harvesting techniques largely used in Rajasthan and sometime in UP areas. This is basically cylindrical paved underground pit for harvesting, roof water, rainwater or runoff water which comes in and then this they can pass

through this and then they go inside and stored in that tank. So, this kind of structure we call as taanka.