Environmental Science
Lecture 25

Why not RWH?

Why does Rain water harvesting not work? The few reasons why it cannot be used is; it is not applicable in all climatic conditions all over the world. Performance is seriously affected by climate fluctuations that are sometimes very hard to predict. Increasingly sophisticated RWH systems (ASR) necessarily increases complexities in cost, design and operation, maintenance, size and regulatory permitting. Collected rainwater can be degraded with the inclusion of storm water runoff. Collected water quality might be affected by external factors. Collection systems require monitoring and continuous maintenance and improvement to maintain desired water quality characteristics for water and end-use. Certain areas will have high initial capital cost with low Returns of investment.

Another important factor here when are discussing pollution is the quality of the rain. It could be acidic rain like the acid rain we are discussing in number of our lectures. If the quality of the water is very acidic, it is actually going to pollute the ASR or the aquifer or the ground water. It needn't always work everywhere.

If you look at a typical water cycle we have evaporation from the surface water, evapo transpiration from plants, infiltration to groundwater from precipitation, condensation from the clouds in the form of precipitation. The formation of clouds happens through evapo transpiration and evaporation. Once the clouds are formed via condensation, it comes down as precipitation and precipitation can be taken directly into the ground water and then it enter the aquifer or it goes as surface runoff and back into the lakes and seas.

If you look at rainfall definitions which are pertaining to this; Intensity - Quantity per time of the rainfall event which could be mm/hour. Duration - period of time for the precipitation event. Average Annual and monthly precipitation - average rainfall over one year period and monthly intervals and usually based on 30 or more years of data. Only based that data can we decide if its a suitable location for rainwater harvesting. How do we go about harvesting rainwater? Broadly you have two ways of harvesting rainwater; surface runoff harvesting. In urban areas rainwater flows away as surface runoff. This runoff could be caught and used for recharging aquifers by adopting appropriate methods. Roof top rainwater harvesting- it is a system of catching rainwater where it falls. In rooftop harvesting, the roof becomes the catchments and the rainwater is collected from the roof of the house/building. It can either be stored in a tank or diverted to artificial recharge system. This method is less expensive and very effective and if implemented properly, it helps in augmenting the groundwater level of the area.

Rainwater as source water design considerations - first you have the roof, then you have the screen, then comes the discharge of water, then you have the prefilter, then we have the storage tank. The storage tank is connected to a floor meter where the rod water tank or aquifer is connected and then we have the storm water drainage at the base of it which actually has the stormwater discharge. Which means, anything from the storage tank with the impurities can directly go off to the stormwater drainage. Anything above this level, at the floor meter, above that it is sediment free, it is considered good quality water and goes to the aquifer or the final storage tank. Anything with impurities and sediments goes to the stormwater drainage. It is a very simple setup which can easily be understood by everybody.

Groundwater recharge - under natural conditions it may take days to centuries to recharge groundwater by rainwater. As we need to replenish the pumped water, artificial recharge of groundwater is required at some locations. This is considered the recharge area and this is the water table divide. Here you have the levels marked and this is considered the discharge area. It could be artificially pumped into this, to ensure that the groundwater and this is done by studying the floor lines of the area over there and then a particular Estuary is chosen, then the water is pumped into it to ensure the water table is artificially recharged. Appropriate technology - water conservation and groundwater recharge techniques; water harvesting cum supplementary irrigation techniques in Jhabua. This was used as a way to irrigate fields as well as proper irrigation in a way such that even the plants are not over irrigated, causing floods sometimes and such that the water is used to the appropriate level required by that crop. Crops are designated and assigned to areas based on the water that is available for irrigation. As a climate responsive act, what usually happens is, farmers whose crops based on their value. Cash crops are preferred and in a country like India, most crops can grow in most areas unless you are talking about hilly areas and places like that. The new concept is, we need to take into the consideration the water that is available, the irrigation technique that is available and even every crop that is bought and planted by the farmer, a particular irrigation technique that is taught to him to ensure that water is consumed to the level that is required and not a drop more.

Ground catchments systems channel water from a prepared catchment area into storage. Generally they are only considered in areas where rainwater is very scarce and other sources of water are not available. They are more suited to small communities than individual families. If properly designed, ground catchment systems can collect large quantities of water. Storage devices maybe either above or below the ground, different types include storage types, water containers, lagoons or line ponds, infiltration ponds. The size is based on rainfall pattern, demand, budget, area and the population it is catering to as well. This is a percolation pit to drive out rainwater into an aquifer. The percolation pit is covered with a perforated concrete

slab as you can see in the image here. The pit is filled with gravel or pebbles followed by river sand for better percolation. It's basically a filtration system. The top layer of sand must be cleaned and replaced at least once in two years to remove settled silt for improving the quality of percolation.

Rain water harvesting methodologies - we have seen a couple of these methods but when you look at urban and industrial environment, you have roof and land based RWH. Public, private, office and industrial buildings can also have a similar system but in a larger scale. Pavements, lawns, Gardens and other open spaces can have direct channels located such that the water can directly be used to recharge the groundwater. These are recharge wells. The runoff water from rooftops or other catchments can be channelized into an existing or new well via sand filter to filter turbidity and other pollutants. Abandoned wells can also be used. This is a cost-effective process, which not only conserves rainwater for immediate use but also helps to enhance the local ground water situation. Here, we have two filtration systems and a recharge well to collect the water before it gets collected into the aquifer or the ground water.

Quality issues - roofs contain bird droppings, atmospheric dust, industrial and urban air pollution. Operational procedures and design considerations - the storage tank should be made using dark materials to exclude light and algae formation. Corrosion resistant materials, tank in a protected shaded area, we need to lower the temperature. For multiple storage tanks, that are designed for frequent turnovers. Regional wind direction and industrial activity such that we know where heavy metal pollution is happening like lead, mercury and other heavy metals.

Principals of a green building with respect to water. System of rainwater harvesting and greywater are combined to achieve the following; 25% of potable water consumption reduction, 100% of potable water provided by rain, 50% reduction of sewer quantities. A number of these green building technologies are actually helping. At first, you have waterless flushes, second you have the grey water - where the sewage treated water can be reused. If the sewage treatment plant works well. 100% of the water can be changed to potable water but it can be used by the lawns, by the cooling towers, by the flush system, all of these can be reused.

Watershed Management and Development

A watershed is defined as a geo hydrological unit that drains into a common point into a system of drains. All lands on earth are a part of one watershed or another. The words watershed, catchment, basin, drainage area are synonymous and in Indian usage, pertain to an area and not a line. The terms micro, mini, sub-watershed or any other variation of the terms indicate hierarchical division of the watershed of a stream, river or a drainage line.

Importance of a watershed - watersheds basically sustain all kind of life in more ways than one. According to the Environmental Protection Agency, more than 450$ billion in foods, fibre, manufactured goods and tourism depend on clean, healthy watersheds. Healthy watersheds are also important for the very sustenance of human life. How do we go about managing these watersheds? Watershed management is defined as the process of formulating and carrying out course of action involving manipulation of natural, agricultural and human resources of a watershed to provide resources that are desired by and are suitable to the watershed community. The watershed management and exploitation should not have any adverse effects on soil and water resources. It is an integrated and multidisciplinary approach.

Objectives of watershed management - Protecting, conserving and improving the land resources for efficient and sustained production. Protecting and enhancing water resources, moderating floods, reducing silting up of tanks/reservoirs, increasing irrigation and conserving rainwater for crops and thus mitigating droughts. Utilizing the natural local resources for improving agriculture and allied occupation of industries so as to improve socio-economic conditions of local residents.

Perspectives of watershed development - Hydrological aspects, Environmental aspects, socio-economic aspects, financial aspects and administrative and political aspects. Approach for watershed management and development. People's participation is key to watershed development programmes. While the main development activities have to be carried out by the watershed community itself, the overall facilitation, coordination and supervision of the whole programme will be the responsibility of a project implementation agency or PIA. The whole setup for the watershed management follows a hierarchical approach.

Steps for preparation of an integrated watershed management plan. The preparation of watershed development plan includes two main steps; the first step is to Identify watershed problems. Setting up of objectives and priorities based on various surveys of watershed. Formulation of proposed development and management plan.

These are the geological aspects of watershed management and development. Natural resources and natural hazards. Natural resources are soil and water. The hazards are earthquakes, floods and landslides. Soil and water conservation methods for watershed treatment - soil and water conservation measures to be employed depend on the purpose for which land and water is to be used. There are two broad categories - Soil and water conservation measures for agricultural land. Second is, erosion control measures for non-agricultural land.

Soil and water conservation measures for agricultural land - contour bunding, graded bunding or channel terraces, bench terracing, grassed waterways, strip cropping, mulching and subsoiling. Natural hazards like floods, earthquakes and landslides which actually help with non-agricultural land and removal of topsoil in those conditions. If you look at floods - the management of rainfall and resultant runoff is very important to control floods and found to depend on watersheds. Due to floods, the plains have become silted with mud and sand that affect the cultivable lands, watershed management thus helps to reduce the rate and quantity of the sediment to be deposited. The excess runoff from streams during monsoon can be controlled using techniques like check dmas, percolation dams, etc. This results in mitigation of floods, recharge of groundwater which can be used during times of drought.

Earthquakes while developing a watershed, the zone of hazard in which the area falls should actually be kept in mind. If lineaments such as folds, faults, joints, etc are more at a place where a watershed is to be developed, then the area is more earthquake prone. The structures developed must be earthquake resistant if the area is in a hazardous zone. How do we go about earthquake preparation? The objective of earthquake engineering is to foresee the impact of earthquakes on buildings and other structures and to design such structures to minimize the risk of damage. Existing structures can be modified by seismic retrofitting to improve their resistance to earthquakes. Emergency management strategies can be employed by a government or organization to mitigate risks and prepare for consequences. Emergency management strategies can be employed by a government or an organization to mitigate risks and to prepare for such consequences if they occur. A landslide is a geological phenomenon which includes a wide range of ground movement such as rock falls, deep failures of slopes and shallow debris flows. Although the action of gravity is the primary driving force for a landslide to occur. You have other contributing factors affecting the original slope stability. Typically, pre-conditional factors build up specific subsurface conditions that make the area/slope prone to failure, whereas the actual landslide often requires a trigger before being released.

Watershed and drainage patterns - the drainage patterns have their effect on watershed development as they decide on the type of sedimentation process and quantity of sediments and water. The drainage patterns also give ideas of lithology and relief. For example, the development of dendritic to sub dendritic drainage in the watershed indicates the area of massive rock types. Gently sloping to almost horizontal terrain and low relief. It has been suggested that the parallel drainage in Deccan Basalt terrain is initiated due to the step like nature of the Deccan traps which is joined by subsequent lateral ravines giving a sub-parallel pattern. Since everyone is actually part of a watershed, we need to be very careful about what do we actually pour down our drains. We should never pour down toxic household chemicals down the drain, you have to take them to a hazardous waste centre. Recycle yard waste in a

compost pile and practice mulching and we need to make sure we adopt a watershed and we are more aware. Watershed is something that no one is aware of. We need to be aware of our watershed and what are the implications of it as well.

Resettlement and Rehabilitation

Moving on to resettlement and rehabilitation; what happens with resettlement is, any disaster like we just discussed, let it be earthquakes, floods, landslides, any such disaster; a particular population transfer or resettlement is basically the movement of a large group of people say from region to another often as a form of forced migration, imposed by state policy, international authority and most frequently on the basis of ethnicity or religion. Banishment or exile is also a similar process but that is forcibly applied to individuals and certain groups. Often the affected population is transferred by force, to a different region, not suited to their way of life causing them substantial harm. In addition, the loss of all immovable property and when rushed, the loss of all substantial amounts of movable property is implied. This transfer may be motivated by the more powerful party's desire to make other uses of the land in question or less often by disastrous environmental or economic conditions that require relocation. Two reasons resettlement occurs; one for highway expansion, when a particular road has to be widened, when a flyover has to be built, this is one of the reasons resettlement occurs. The second is when natural disasters or man made disasters forcibly move people out of a particular region.

Rehabilitation is the restoration of someone to a useful place in society. The conversion of wasteland into land suitable for use of habitation or cultivation. The act of restoring something or someone to a satisfactory state. The state of being restored to its former good condition. This could apply to both people as well as the place. Land rehabilitation is the process of returning the land in a given area to some degree of its former state after some process has resulted in its damage. Many projects and developments will result in the land becoming degraded. The main primary example being mining, certain kinds of farming and forestry as well. Although land rehabilitation is often used to rectify problems, caused by man made process such as drilling, mining and other petrochemical related processes, it is also used to clean up natural processes. For example - natural disasters such as earthquakes, flooding can also cause damage to the natural environment. Land rehabilitation techniques can be used to speed up the amount of time necessary to restore the location back to its original state. The demand for rehabilitation has increased during the last few decades as resources firms have become increasingly environmentally conscious and new environmental protection laws have been introduced. However, rehabilitation is a very costly process especially if there is a toxic cleanup that's required post a chemical spill or a mining process.

Mine rehabilitation - after particular mining finishes, the mine area has to undergo rehabilitation before it can be used for any other purpose. Waste dumps are contoured to flatten them out, to further stabilize them against erosion. If the ore contains sulfides it is usually covered with a layer of clay to prevent access of rain and oxygen from the air, which can oxidize the sulfides to produce sulfuric acid. Landfills are covered with topsoil, and vegetation is planted to help consolidate the material. Dumps are usually fenced off to prevent livestock denuding them of vegetation. The open pit is then surrounded with a fence to prevent access and it generally eventually fills up with groundwater. Tailing dams are left to evaporate, then covered with waste rock, clay if need be and soil which is planted to stabilize it. You can see the process it takes. 2 - 3 years is when some growth or life can start and finally we are looking at 25 - 30 years when this level of forestry can be attained. This phasing happens anywhere between 0 - 25 years and the minimum period we are looking at is 2 - 3 years.

The typical case study we are looking at according to the world commission on dams, WCD between 40 - 80 million people worldwide have been physically displaced because of dam construction. In China by the 1980s, roughly 10 million people were counted as reservoirs resettlers while in India, estimate of the populations displaced by the large dams range from 21 million to 33 million people. Displaced and affected people rarely received complete and adequate information on the dam project. The nature and extent of displacement and provisions for resettlement and reconstruction. Displaced and affected people normally have no role in generating baseline information or in developing resettlement plans. The relocation process is often traumatic, involuntary and prolonged. Compensation is inadequately assessed and monitored. Resettlement sites are plagued by poor infrastructure and problematic relationships with host communities.

The transition is never smooth and it is usually thrust upon poor people, uneducated people and tribal people. It is never thrust upon cities and urban people who can fight for their rights.

Studies of persons in China resettled because of dams indicate that they are often left in poverty. A study measuring the effects of displacement due to dam construction stated that only one third of those resettled had 're-established their lives at satisfactory standards'. Another third had returned to 'subsistence livelihoods' while the remainder were 'mired in poverty'. World bank evaluations of dam resettlements indicate that resettlers experience high rates of unemployment and often remain dependent upon food rations from the government. Sixty percent are believed to live below the poverty line. It is because this kind of transition is never monitored, it is very difficult to keep track of the people who are the final resettlers and these people are treated as refugees or unwanted people in new communities or people who are stealing their jobs, their resources, they are never given the same chances. India is actually one of the largest developing projects in the world and quite possibly, the largest number of

development-induced displaced people in the world as well. The India Social institute estimated there were currently 21.3 million persons displaced because of development projects; of this number 16.4 million were displaced by dams. According to the Central Water Commission 3,300 dams had been built since 1947 and another 1,000 are under The Indian Institute of Public Administration estimates that the average number of people displaced by a large dam is 44,182.73.

Among the best known and most controversial cases of development-induced displacement in India is that of the Sardar Sarovar dam and irrigation complex on the Narmada River. Although the Indian Government had been studying displacement of the Narmada River Basin for several decades since independence, full-scale construction of the dam did not begin till 1987, overseen by the Narmada Control Authority and funded initially by the World Bank.