Course Name: Watershed Hydrology

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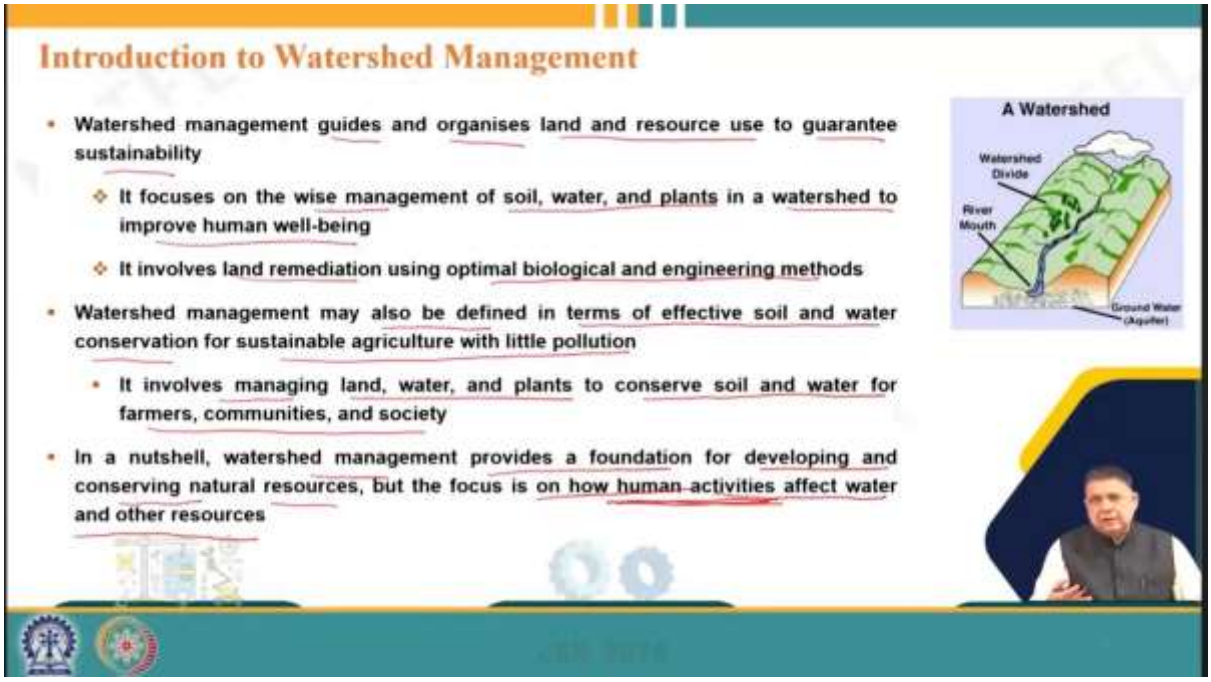
Week: 07

Lecture 34: Watershed Management I

Hello, friends! Welcome back to this online certification course on Watershed Hydrology. I am Rajendra Singh, a professor in the Department of Agriculture and Food Engineering at the Indian Institute of Technology Kharagpur. We are in Module 7, and this is Lecture 4, where we will discuss watershed management, Part 1.

In this lecture, we will introduce watershed management, discuss watershed management programs in India, and outline the general steps of watershed management planning.

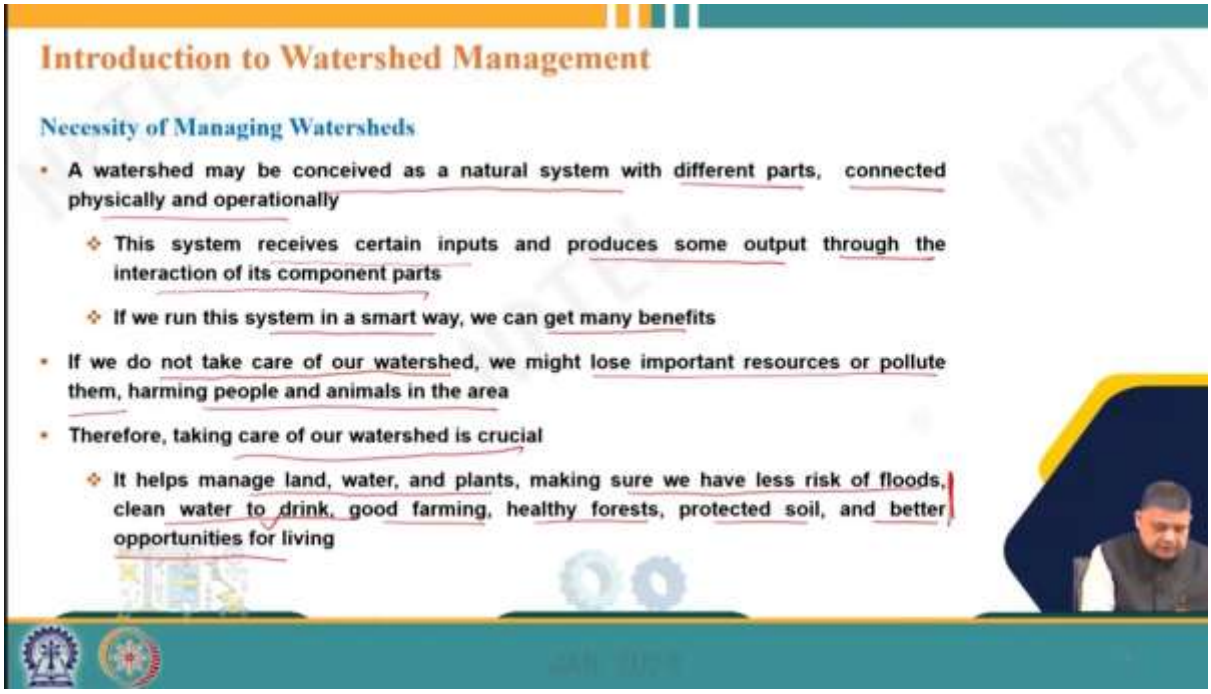


Starting with watershed management, essentially, watershed management guides and organizes land and resource use to guarantee sustainability. It focuses on the wise management of soil, water, and plants in the watershed to improve human well-being. It involves land remediation using optimal biological and engineering methods. So, when we say watershed management, we look at all possible ways of managing our resources in the best possible manner, ensuring sustainability for not only this generation but also the coming ones.

Watershed management may also be defined in terms of effective soil and water conservation for sustainable agriculture with minimal pollution. This involves managing land, water, and

plants to conserve soil and water for the farming community and society. So, effectively conserving our soil, water, and other resources for sustainable agriculture and ensuring minimal pollution will help manage our resources effectively.

In a nutshell, watershed management provides a foundation for developing and conserving natural resources, with a focus on how human activities affect water and other resources. A crucial component of watershed management is the stakeholders or the people living in the watershed who are the consumers of all the watershed resources. It is partially their responsibility to look after these resources in the best possible manner to ensure sustainability.

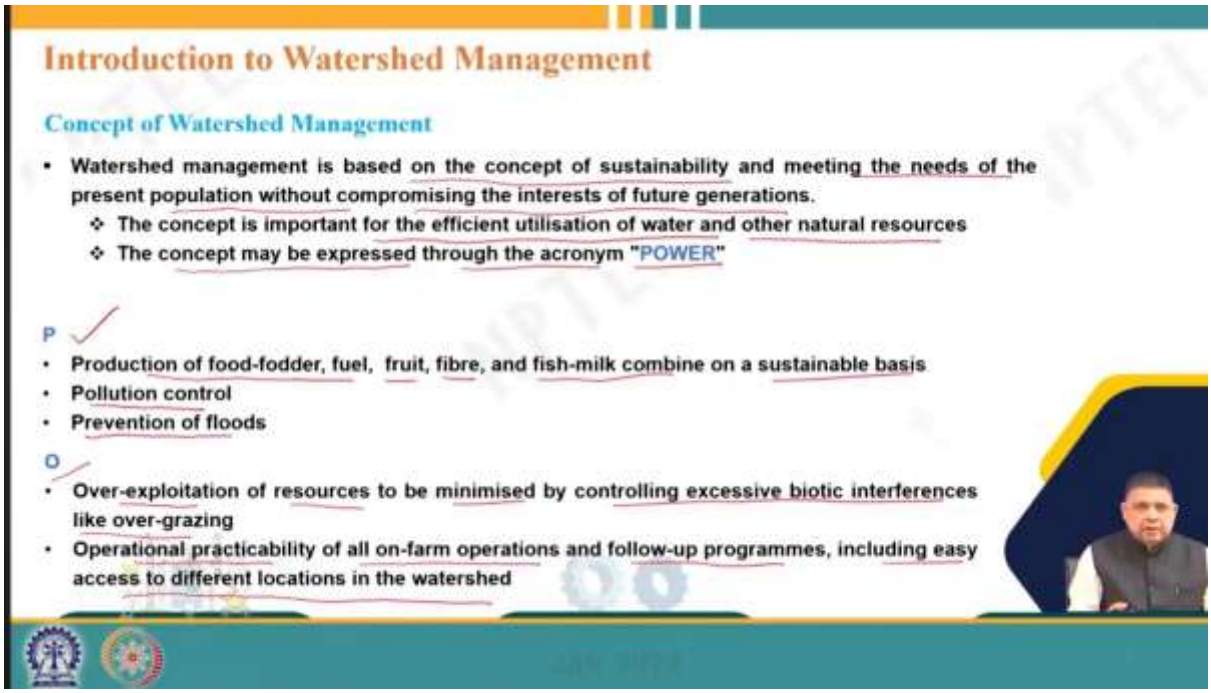


Now, why do we want to manage watersheds? We want to manage watersheds because they may be conceived as natural systems with different parts connected physically and operationally. This system receives certain inputs and produces some outputs through the interaction of its parts. So, if we manage this system smartly, we can derive many benefits.

So, as I mentioned, it includes all aspects: social, economic, and physical. If we care for the system in a better way, then everyone involved in this watershed process will benefit. If we do not take care of our watershed, we might lose important resources or pollute them, harming people and animals in the area. So, the converse is also true: if you do not manage the resources well, then obviously, you will lose the resources over time and also pollute them, making them unavailable or unusable for people in the watershed, currently or in the future. Therefore, taking care of our watersheds is crucial. It helps manage land, water, and plants, making sure we have less risk of floods, clean water to drink, good farming, healthy forests, protected soil, and better opportunities to live.

So, if we look at or manage our watershed properly, then we will take care of all the problems like floods and pollution. And then, obviously, we will have safe drinking water, and good quality food available, and we will have safe routes available because our forest will be managed properly, with the soil protected. So, there is no question of soil erosion. So, our yields

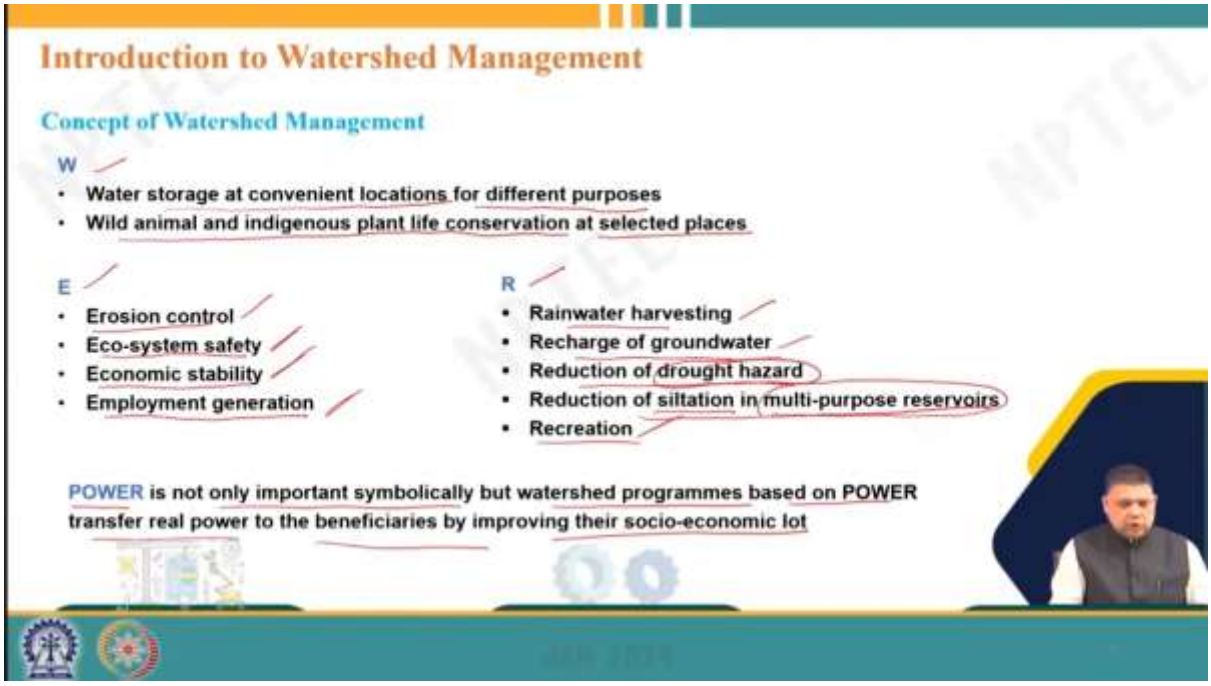
will be high, and of course, there will be better opportunities for living, as the conditions will be favourable from all aspects. That is why managing watersheds is necessary.



Now, coming to the concept of watershed management, watershed management is based on the concept of sustainability, which is what we defined right at the beginning: meeting the needs of the present population without compromising the interests of future generations. So, when we say management, it means that we sustain sustainability, meaning that we want the resources to be available or to be conserved for being available for future generations as well. The concept is important for the efficient utilization of water and other natural resources. This concept may be expressed through the acronym POWER, which stands for several aspects that help us understand the meaning of the concept of watershed management.

If we look at the letter P, it refers to the production of food, fodder, fuel, fruit, fibre, fish, and milk combined on a sustainable basis. That means conditions should be good enough to sustain the production of food, fibre, fodder, fuel, fruit, fish, milk, or whatever is needed for society. Then, P also means pollution control, ensuring that you maintain your resources in such a way that there is no pollution, ensuring a healthy environment. And of course, you will be managing your watershed through various measures, so obviously, the dangers of floods or droughts will also be taken care of; they will be prevented.

The second letter is O, which refers to the overexploitation of resources being minimized by controlling excessive biotic interferences like overgrazing. So, if we want to minimize the overexploitation of resources, we must check. One such example is overgrazing; we must check overgrazing so that our soils and land can be protected. Then, operational practicability of all farm operations and follow-up programs, including easy access to different locations in the watershed. So, you must have facilities so that all follow-up farm operations or follow-up programs can be easily undertaken by people so that the areas must be accessible. All this will be a part of this watershed management program.

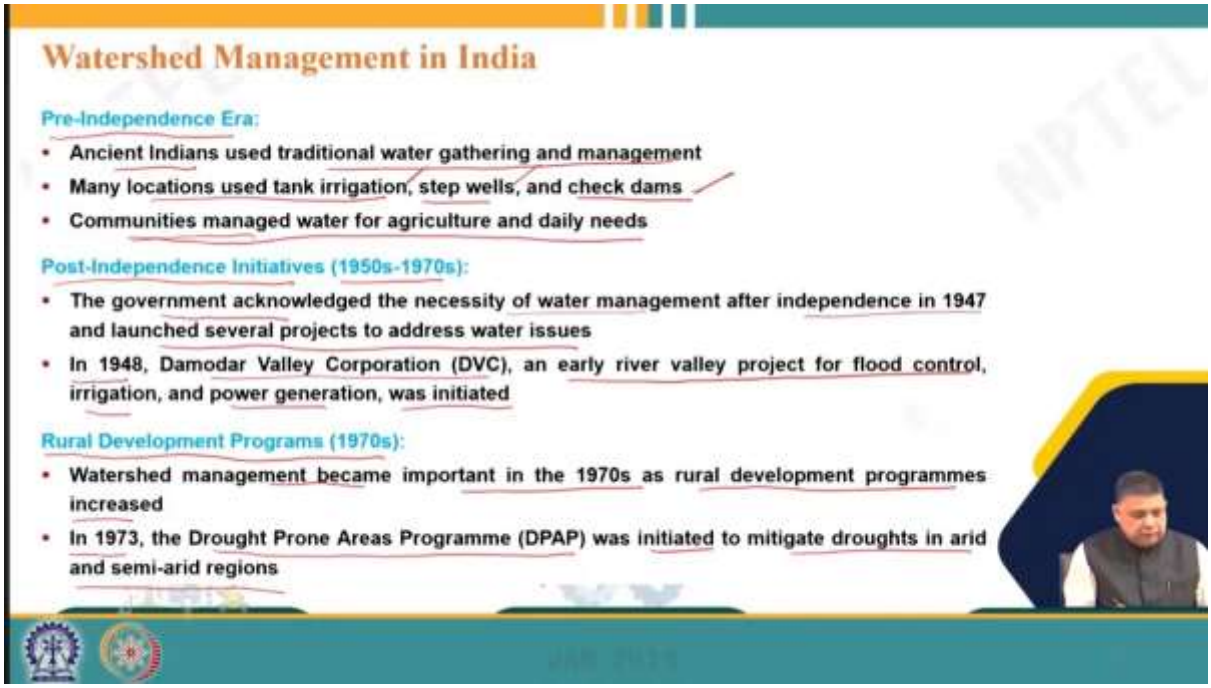


Then, W refers to water shortage, convenient location of water storage at convenient locations for different purposes, and conservation of wild animal and indigenous plant life at selected places.

So, there should be enough water conservation or water storage facilities available at different parts of the watershed so that water is readily available for people for various purposes, maybe drinking or irrigation, and so on. Similarly, the wild animals and indigenous plants should also be conserved within the watershed at suitable locations. Then, the next letter is E, which refers to erosion control, ecosystem safety, economic stability, and employment generation. So, you want to conserve soil and other resources.

So, you do not want erosion to take place, and the safety, I mean, the ecosystem should be preserved so that there will be economic stability, and of course, there will be employment generated within the watershed so that people do not have to move away from the watersheds. Then the last letter is R, which refers to rainwater harvesting, recharge of groundwater, reduction of drought hazard, reduction of siltation in multipurpose, and recreational areas. So, that means, you create such an environment that rainwater is harvested, so that no water is allowed to go to waste. Similarly, groundwater recharge is healthy so that you have enough water available to control drought. And of course, through water conservation and soil conservation measures, you will create conditions so that the reservoirs or water storage facilities are not silted and their capacity is not compromised.

Now, of course, when these water bodies are there, then recreational facilities are also available for people in the watershed. Power is not only important symbolically, but watershed programs based on power transfer real power to the beneficiary by improving their socioeconomic lot. So, that simply means when we look at the concept of watershed management or we expand the acronym POWER, we see that it includes almost all actions that are required for providing a better social and economic life to the people living in the watershed. So, that is the concept of watershed management: you want to strengthen the economy and the economic well-being as well as the social well-being of people living in the watershed.



Then, looking at watershed management in India if we look at the pre-independence era, then ancient Indians used traditional water gathering and management; many locations were used for creating tank irrigation, step wells, and check dams; communities managed water for agriculture and daily needs. So, obviously, during the pre-independence era when the science of conservation was not so developed or not well-read, people were still taking care, meaning they were creating water storage facilities in terms of tank irrigation or step wells, or they were creating check dams so that erosion could be controlled, and the velocity of flow could be controlled, and, of course, it was all managed by the communities themselves.

Then, if we talk about post-independence initiatives, that is during the 1950s and 1970s, then the government of India acknowledged the necessity of water management or watershed management after independence in 1947 and launched several projects to address water and watershed issues. As a result, in 1948, the Damodar Valley Corporation (DVC), popularly known as DVC, an early river valley project for flood control, irrigation, and power generation, was initiated. So, the Damodar Valley Corporation, which is headquartered in Jharkhand, now earlier Bihar, now Jharkhand, was the first river valley project targeting flood control, irrigation, and power generation; that is a multipurpose river valley project.

Then, within the 1970s, some rural development programs were initiated, so watershed management became important as rural development programs increased. In 1973, the Drought Prone Areas Program (DPAP) was initiated to mitigate droughts in arid and semi-arid regions. So, the focus was more on rural development, and the targeted areas were drought-prone areas like arid and semi-arid regions, and targeting them, this DPAP, that is, the Drought Prone Areas Program, was initiated in 1973.

Then, in the 1980s, watershed development projects were initiated; the government launched the National Watershed Development Program for Rainfed Areas (NWDPRA) in the mid-'80s to address rainfed areas. So, initially, we started with river valley projects; then we targeted drought-prone areas, and then the target moved to rainfed areas in the mid-'80s. And then, of course, the Integrated Watershed Management Program (IWMP) was taken. So, the Ministry of Rural Development launched IWMP in 2009 to combine watershed development programs. So, during this process, when the Ministry of Rural Development launched this IWMP, then all existing programs focusing on watershed management were taken under one shelter, that is, the Integrated Watershed Management Program. Community participation, livelihood improvement, and sustainable resource management were stressed during this integrated watershed management program, and we will talk about this integrated watershed management program in detail, maybe in the next lecture.

Then, of course, the path-breaking Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) came, which ensured employment for rural households through MGNREGA, and it was in 2006.

It supported watershed maintenance. So, of course, under this act, there is a provision for providing 100 days of employment to at least one member of each household, and obviously, most of the programs are related to watershed management. Many watershed projects use MENREGA to conserve water in managed soil. So, many of these activities of MENREGA have been focused on watershed management or watershed development in India. This is how watershed management progressed right from independence till today.

Now, if we talk about ongoing watershed management development programs initiated by various ministries, these are listed here. So, this is the Ministry of Agriculture and Farmers Welfare, Department of Agriculture and Cooperation; they have many projects like the National Watershed Development Project for Rainfed Areas. Then, soil conservation in catchments of river valley projects, like Damodar Valley Corporation. Then, watershed development projects in shifting cultivation areas, targeted at areas where shifting cultivation is practiced, mainly in the northeast. Then, there were programs under the Water Development Fund, and of course, there were some externally added projects, EAPH.

These are the programs offered by the Ministry of Agriculture and Farmers Welfare, Department of Agriculture and Cooperation. Then, if you look at the Ministry of Rural Development, that is, the Department of Land Resources, of course, they had the Drought Prone Areas Program (DPAP), Desert Development Program (DDP), Integrated Watershed Development Program (IWDP), and of course, externally assisted programs (EAPH), and the Investment Promotional Scheme supported various NGOs, that is non-government organizations. Also, the Ministry of Environment and Forest had the Integrated Afforestation and Eco-Development Project Scheme.

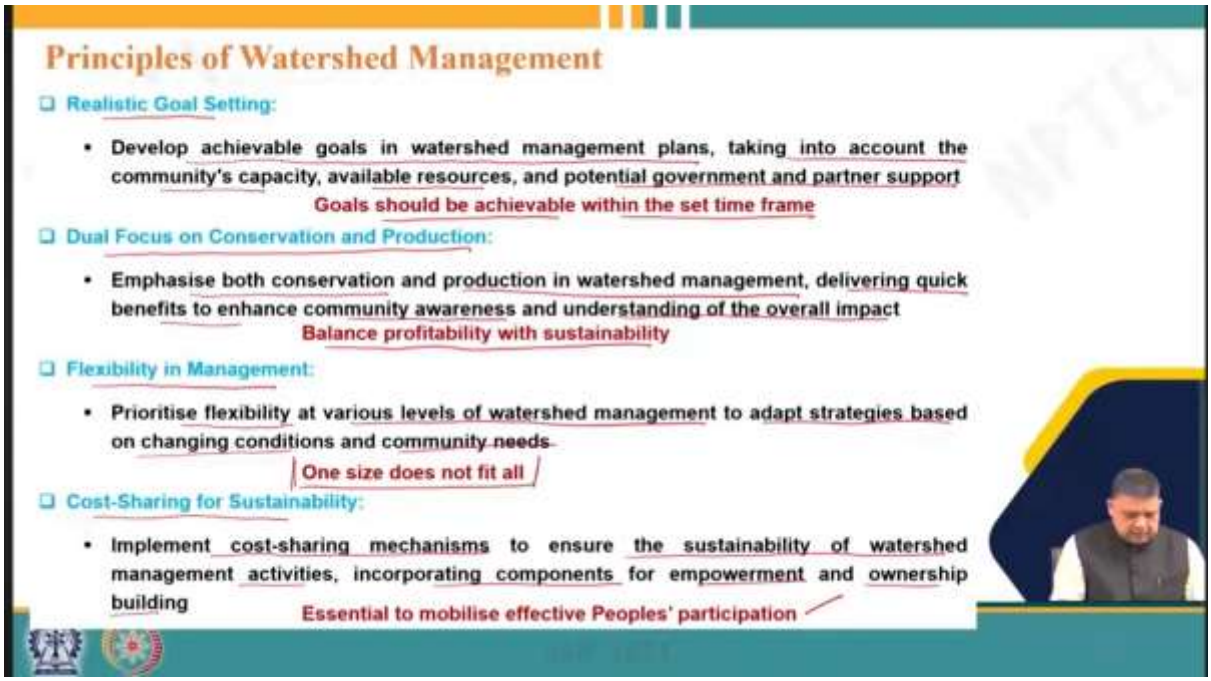
So, as you can see, different ministries have different programs targeted at different areas or various aspects of watershed management in various problem areas around the country. However, as already mentioned, it may be noted that most of the above schemes are subsumed under the Revised Macro Management of Agriculture (MMA) scheme of the Department of Agriculture and Cooperation (DAC) from 2008 to 2009. So, because there were multiple programs managed by different ministries, it was thought prudent to bring everything under one umbrella, and that is why this Revised Macro Management of Agriculture scheme was initiated in 2008-09, and all the existing programs were or most of the programs were subsumed under this Revised Macro Management of Agriculture scheme. This is the status of ongoing programs in India.

Now, we come to the principles of watershed management, and of course, many principles need to be followed. For example, one of the major principles is participatory community engagement. So, of course, this focuses on engaging the community in various tasks with clear roles and responsibilities to enhance the effectiveness of watershed management. So, already we discussed that the target group must be the people living in the watershed. In essence, people's participation is essential for effective watershed management. No watershed program can succeed without the active participation of the people living in the watershed or who are the consumers of resources.

Then we must have multidisciplinary collaboration. I mean, watershed management must promote a continuous multidisciplinary approach involving planners, scientists, outreach experts, ecologists, hydrologists, engineers, economists, stakeholders, and regulators for comprehensive watershed management. So, we see that different watershed management programs have different issues, and that is why you need a group of people, a group of experts, really to be able to handle them, and that is why a multidisciplinary approach is essential. So, a multidisciplinary approach is essential for comprehensive watershed management. That is the take-home message. Then comes the gender-inclusive programs, that is, watershed management programs must ensure gender sensitivity, fostering women's active involvement in planning, implementation, and management to address their vulnerability to environmental challenges. So, you know that, of course, half of the population is women, and women have larger responsibilities in managing their homes as well as managing drinking water.

We know that in TV news, you see women traveling to far-off places to bring water even today. Because they have a lot of responsibilities gender sensitivity is essential to ensure sustainability in watershed management programs. Then integration of local wisdom incorporates local wisdom and considers socioeconomic conditions to enhance existing technologies and introduce new ones to improve natural resource management. So, in a nutshell, local wisdom is essential for the effective implementation of global know-how. Because local people have their local wisdom gained through traditional practices, they know what is good for their land, and what is good for their watershed, to manage their resources.

So, you could bring global know-how, but at the same time, it needs to be tuned by mixing it with local wisdom so that it succeeds for sure in the watershed management program in a particular area.



Then realistic goal setting: develop achievable goals in watershed management plans, considering the community's capacity, available resources, and potential government and partner support. So, you must set achievable goals, so goals should be achievable within the set time frame. If you make your goals too expensive, then obviously, you will not meet the goals, and then there will be failure, and there will be setbacks. So, while setting the goal, one should be realistic.

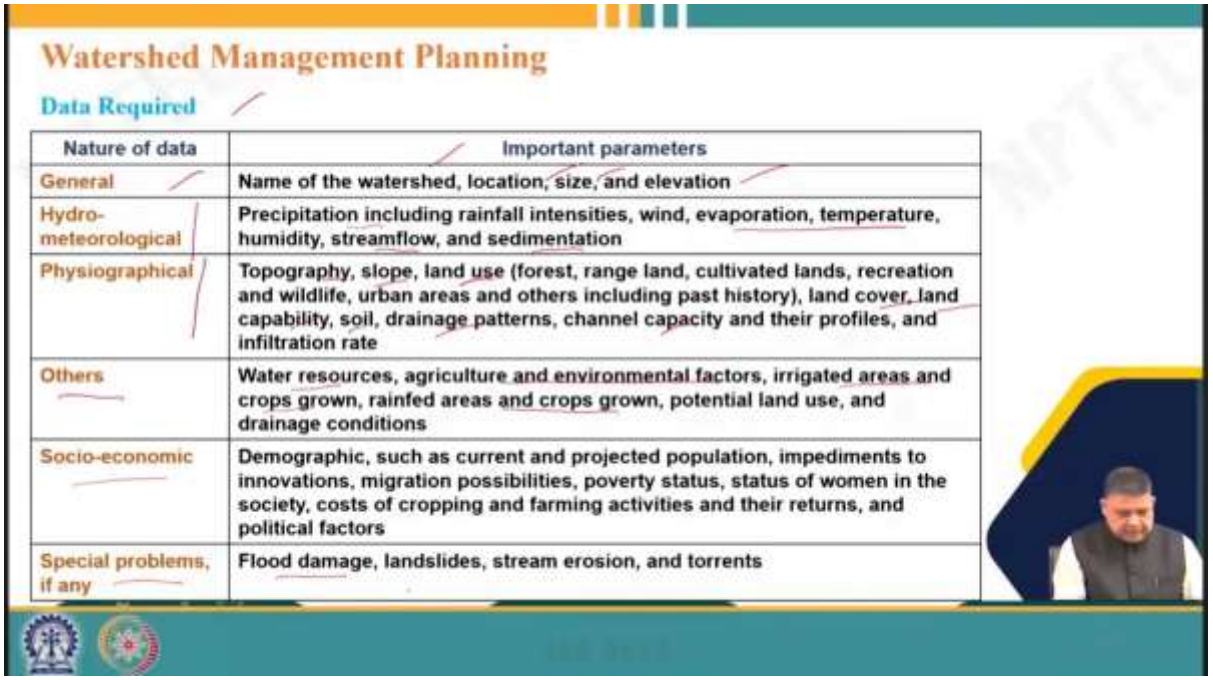
Then there should be a dual focus on conservation and production, emphasizing both conservation and production in watershed management, delivering quick benefits to enhance community awareness and understanding of the overall impacts. So, you cannot just conserve or you cannot just go on producing. So, producing more obviously brings economic well-being, but at the same time, if you do not conserve, then sustainability is lost. So, you must have economic well-being along with sustainability. So, that is why the focus must be both on conservation and production.

So, we need to balance profitability with sustainability in the watershed management program. Then the next principle is flexibility in management: prioritize flexibility at various levels of watershed management to adopt strategies based on changing conditions and community needs. So, the well-known saying that one size does not fit all applies to watershed management also, that something that succeeded at a particular place may not succeed at some other place. So, that is why the programs or objectives or approaches must be flexible according to conditions existing in a particular watershed. Then cost-sharing for sustainability is the next principle: implement cost-sharing mechanisms to ensure the sustainability of watershed management activities, incorporating components of empowerment and ownership building that are essential to mobilize effective people's participation.

This cost-sharing is very important because the moment the people living in the watershed, they have their cost, their money invested into the program, whether money or effort, it could be in cash or kind, if they are the first then they will have the ownership, they will take up the responsibility, and then, of course, they will look towards the success of whatever program is being taken up. So, that is why cost-sharing is essential to mobilize effective people's participation and, of course, to ensure sustainability.

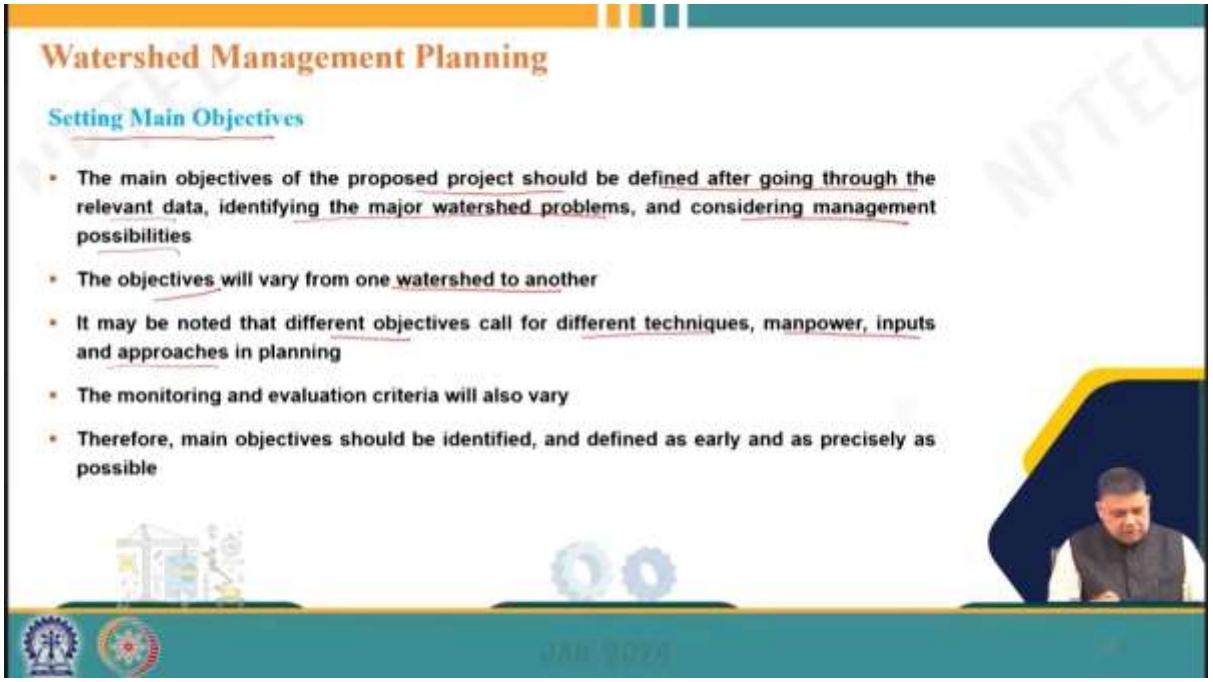
Then alignment with food security and rural development: align watershed management initiatives with goals related to food security and rural development for comprehensive or sustainable outcomes. Of course, because food security and rural development are big challenges, as you know, there is still a huge gap between the urban and rural masses' living standards. So, the watershed management program must look at food security and rural development to ensure resource conservation while looking at the well-being, economic and social well-being, of the masses.

Then we should have a dynamic adaptive approach: we should avoid rigid predetermined action plans; instead, adopt a dynamic approach that accommodates diverse community viewpoints and adjust strategies based on specific watershed differences. So, it is essential to absorb changing ground conditions; we need to have an adaptive approach. And, of course, strategic partnerships and communication: foster partnerships, employ well-planned actions based on scientific principles, and enhance communication to support a dynamic and effective watershed management framework. So, this strategic partnership and communication are essential for a successful watershed management program.



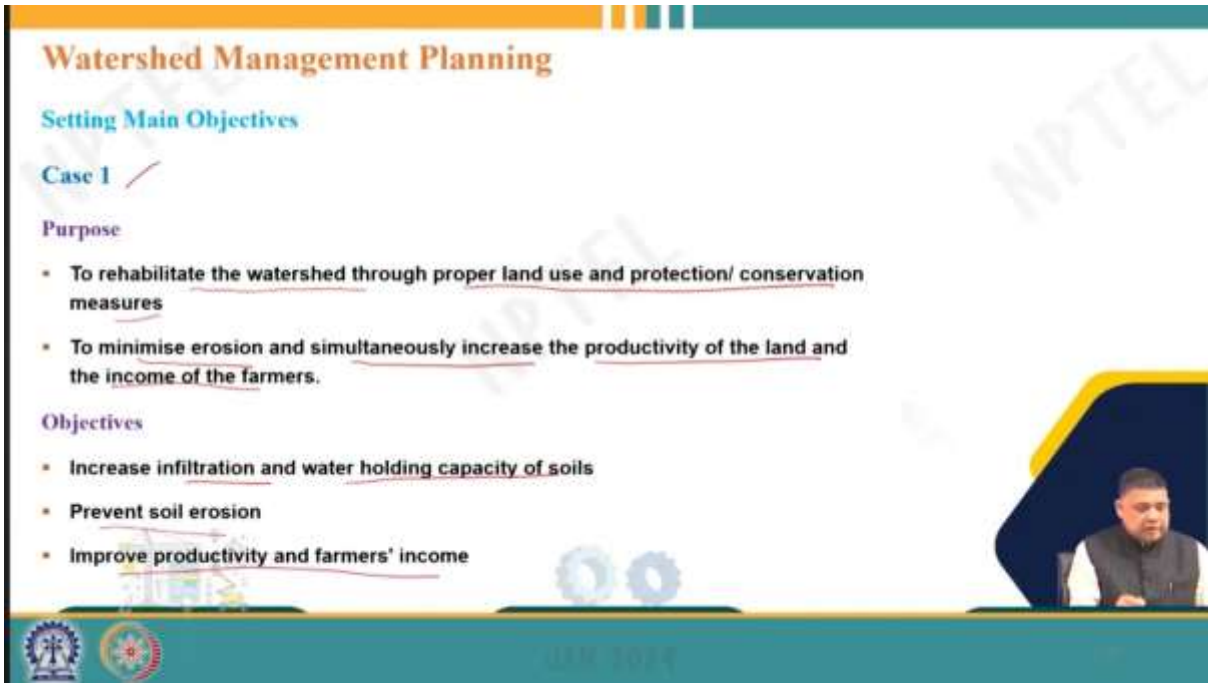
So, coming to the required data, if you look at the data required, then there are various kinds of data like general data: name of the watershed, location, size, and elevation.

Then we have hydrometallurgical data like precipitation, stream flow, sedimentation, and various metallurgical data. Physiographical data includes many characteristics we have already studied, such as topography, slope, land use, land cover, land capabilities, soil, drainage patterns, and channel capacity. Other data include water resources, agriculture, environmental factors, irrigated areas, crops grown, rainfall areas, etc. Socioeconomic and special problems like flood damage, landslides, stream erosion, torrents, and whatever exists, all these data must be available for watershed planning.

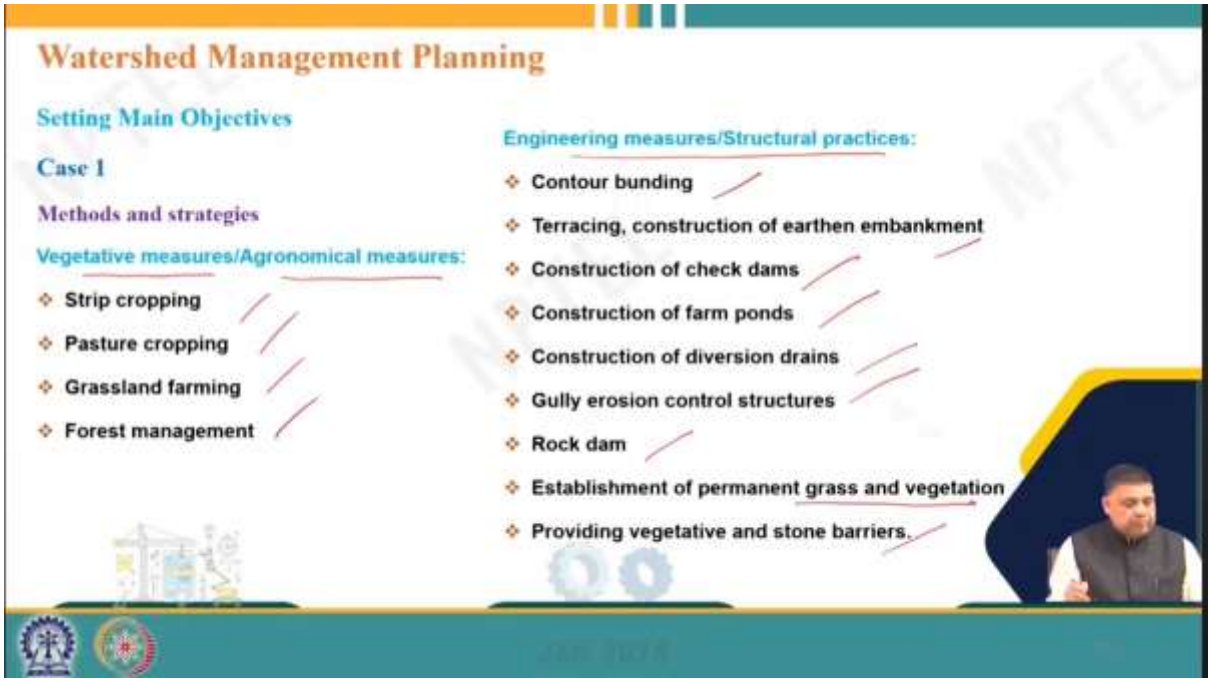


And of course, we need to set the main objective. The main objective of the proposed projects should be defined after going through the relevant data, identifying the major watershed problems, and considering management possibilities. The objective will vary from one watershed to another, and we know that different objectives call for different techniques and manpower inputs; one size does not fit all is true here also.

Monitoring and evaluation criteria will also vary; the main objective should be identified and defined as precisely as possible.

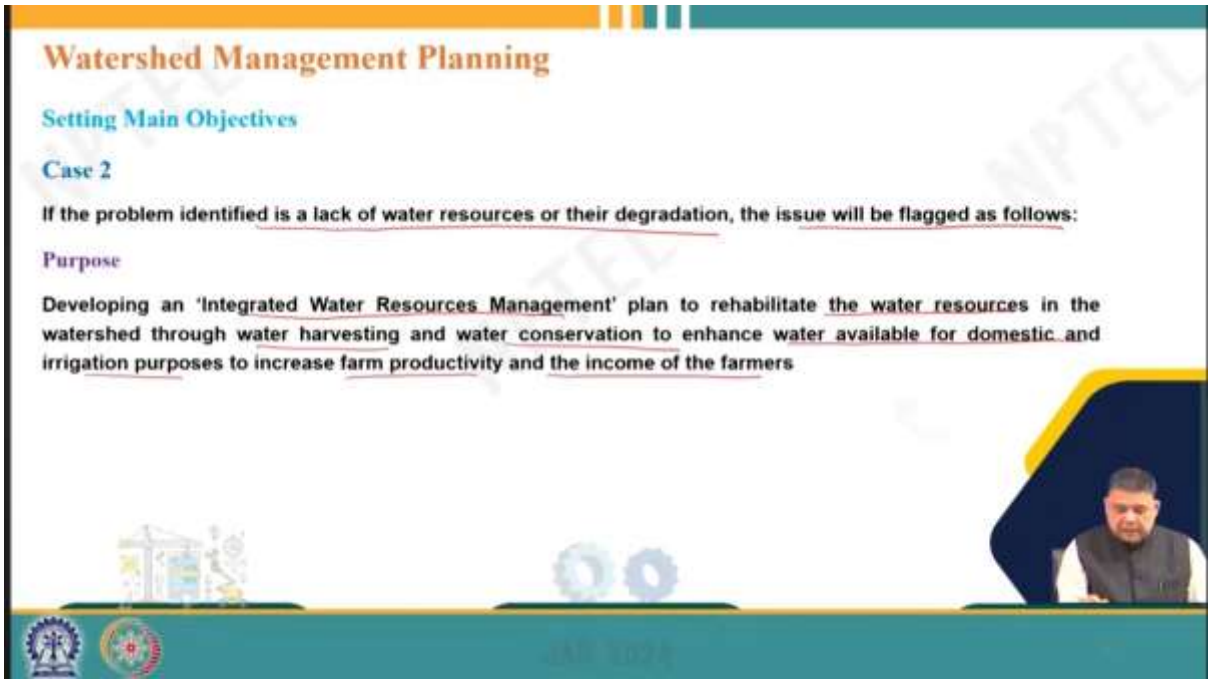


For example, if the purpose, in case one, is to rehabilitate the watershed through proper land use protection and conservation measures, then we need to minimize erosion and simultaneously increase the productivity of land and income performance. Then our objective would be increasing infiltration, water holding capacity of soils, preventing soil erosion, and improving productivity, and farmers' income. So, to tackle these two purposes, we need to have these kinds of objectives.



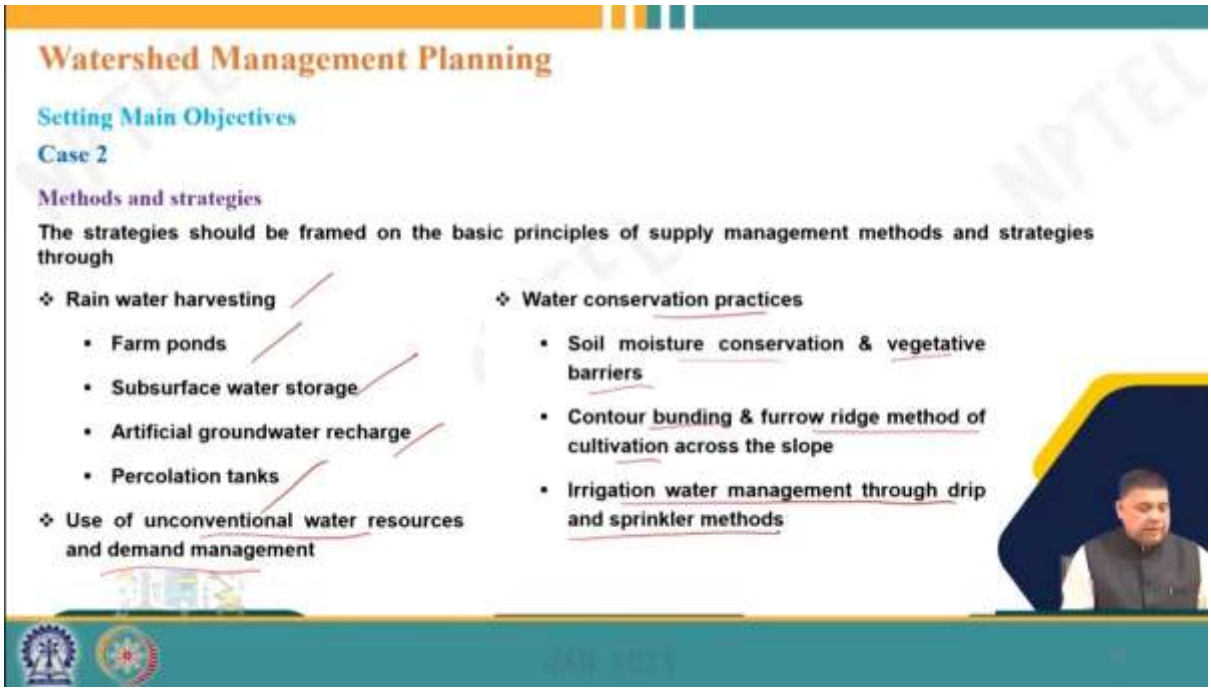
And of course, the methods and strategy could be different; we could take up vegetative measures or economic measures like strip cropping, pasture cropping, grassland farming, and forest management, or we can take up engineering measures or structural measures like contour bunding, terracing, construction of check dams, farm ponds, construction of diversion drains, rock dams, gully control structures, permanent grass, and vegetation, and providing vegetative and stone barriers.

So, depending on whatever is needed to conserve water, which is a focus area for this watershed, that must be done.



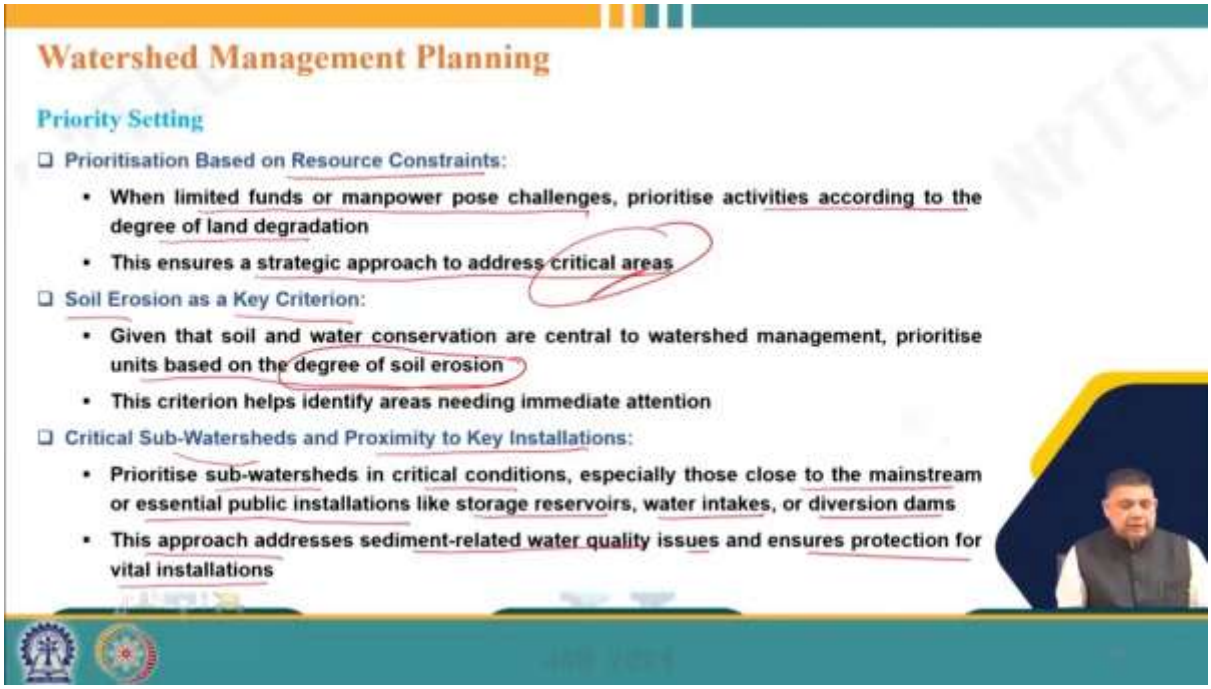
If we consider another case where the problem identified is a lack of water sources and their degradation, issues will be flagged, like developing an integrated water resources management

plan to rehabilitate the water sources in the watershed through water harvesting and water conservation to enhance water available for domestic and irrigation purposes to increase farm productivity and the income of the farmers.



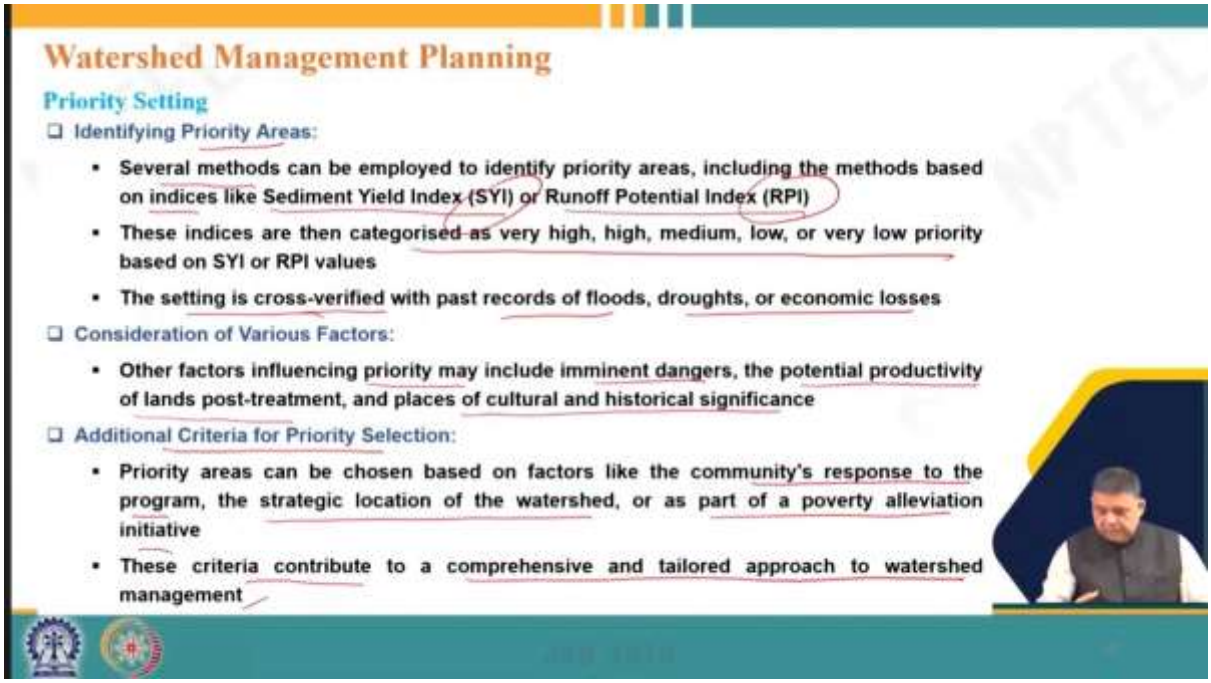
And of course, the objectives will be rainwater harvesting, water conservation, and exploiting unconventional water resources. So, this will be our focus, and then we can accordingly adopt different measures like rainwater harvesting, farm ponds, subsurface water storage, artificial groundwater recharge, percolation tanks, and the use of unconventional water resources. Water conservation measures like soil moisture conservation and vegetative areas, contour bunding, furrow ridge method of cultivation, and irrigation water management through drip and sprinkler systems.

So, whatever is needed to conserve more and more water in the watershed could be stressed. And of course, protecting horizontal species on contour bunds, that is contour farming or contour cultivation.



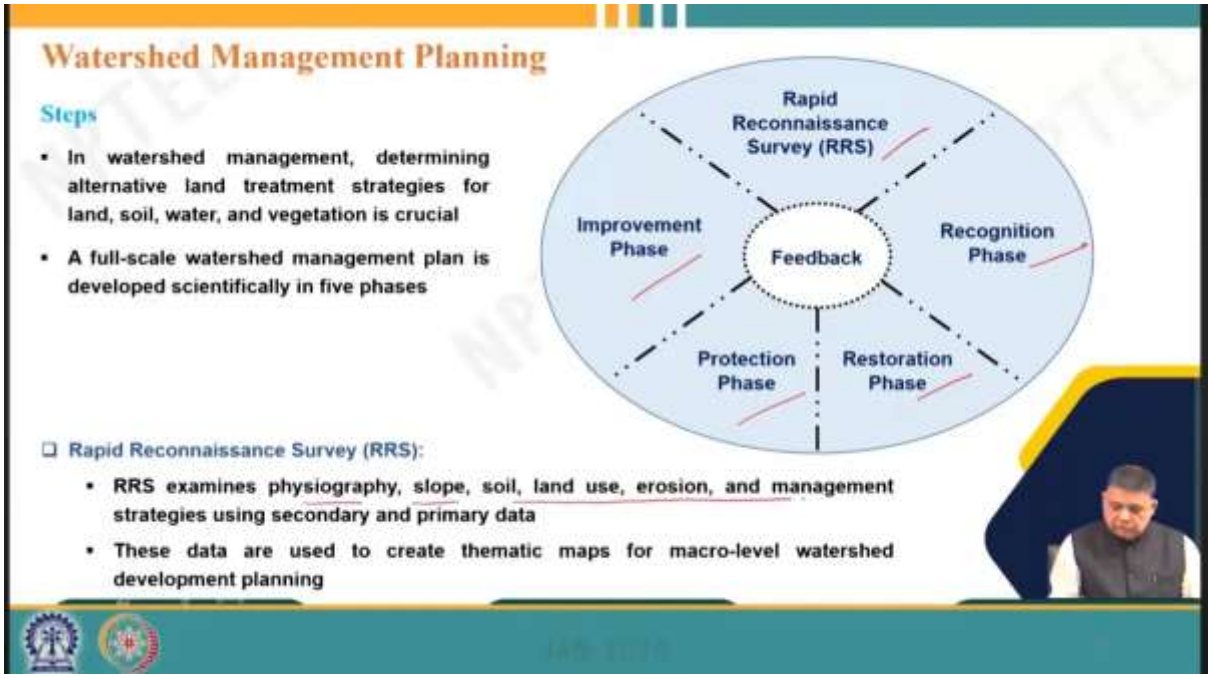
Now, coming to priority setting, we can set watershed management priorities based on different criteria. It could be based on resource constraints, that is, when limited funds or manpower pose challenges, prioritize activities according to the degree of land degradation. This ensures a strategic approach to address critical areas. So, when funds and resources are limited, you will target only the critical areas.

Soil erosion is the next criterion; soil erosion should be focused on, prioritize units based on the degree of soil erosion. So, we will find out soil erosion for different sub-watersheds, and we will prioritize activities based on the degree of soil erosion in different areas. Then critical sub-watersheds and proximity to installations, so we may prioritize sub-watersheds in critical conditions, especially those close to mainstream or essential public installations like storage reservoirs, water intakes, or diversion dams. And of course, these approaches address sediment-related water quality issues and ensure protection for vital installations so that sedimentation in storage reservoirs or structures could be limited.



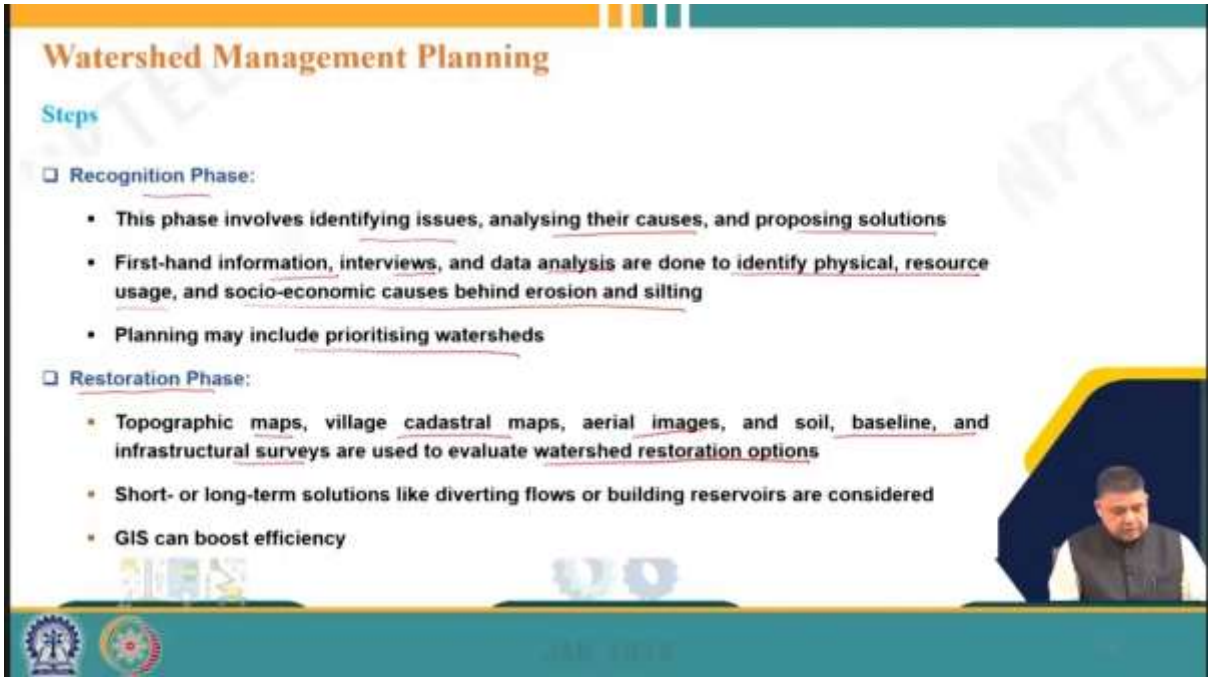
Then, of course, we can identify priority areas based on certain scientific methods by employing various indices, and those indices could be sediment yield index or runoff potential index. And, of course, these indices are then characterized as very high, high, medium, low, and very low priority. And, of course, we need to cross-set and cross-verify the setting with records of floods, droughts, or economic losses. These SYI and RPI will be discussed in detail in the next lecture.

Then considerations of various other factors like imminent dangers, the potential productivity of lands post-treatment, and places of cultural and historical significance can also be used for priority setting. Additional criteria for priority selection could also be used, like community response to the program, and the strategic location of the watershed as part of the poverty elevation initiative. These criteria contribute to a comprehensive and tailored approach to watershed management. So, as you see, we have different possible criteria based on which we can select our watershed.

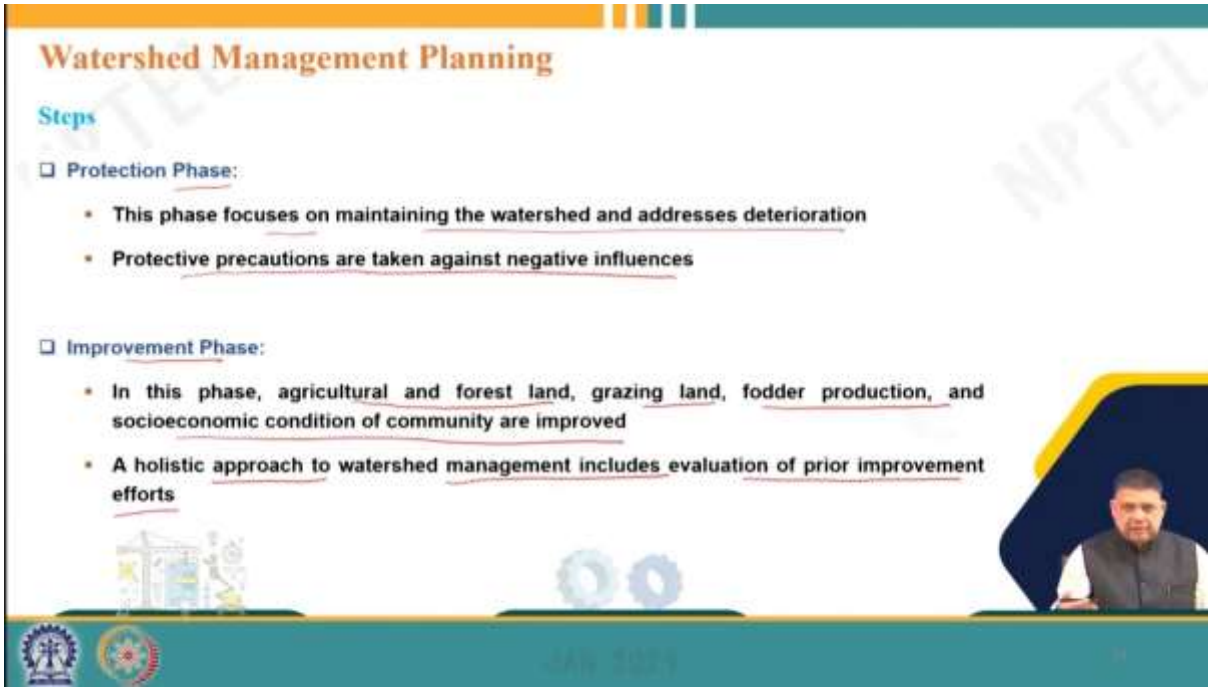


If you look at the steps in watershed management, basically there are 5 major steps: RRS, which is the rapid recognition survey, recognition phase, storage phase, protection phase, and improvement phase. Under RRS, we examine physiography, slope, soil, land use, and erosion management strategies using secondary and primary data. Then we create thematic maps for macro-level watershed development planning.

Under the recognition phase, we identify issues, analyze their causes, and propose solutions. First-hand information interviews and data analysis are done to identify physical resource uses and socioeconomic causes behind erosion and silting. Planning may include prioritizing watersheds. Then we come to the restoration phase where we take up topographic maps, village catastrophic maps, aerial images, and soil baseline infrastructure surveys to evaluate watershed restoration options. Short or long-term solutions like diverting flow or building reservoirs may also be considered, and of course, the application of GIS can boost efficiency here.



Then we have the protection phase, which focuses on maintaining the watershed and addresses deterioration, and protective precautions are taken against negative influences.



And lastly, we have the improvement phase where agriculture in forest land, grazing land, fodder production, and the socioeconomic condition of the community are improved by taking steps. A holistic approach to watershed management includes the evaluation of prior improvement efforts.

So, what happened by taking various measures, whether we have made improvements or not, that analysis also is essential. These are various steps required for watershed management following. With this, we come to the end of the lecture. We have introduced watershed and watershed management programs, various principles, and planning steps. Thank you very

much. Please feel free to give your feedback and raise your questions or doubts, which we will be happy to answer on the forum. Thank you very much.