Environmental Impact Assessment
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Lecture 33
EIA – Water Assessment

Welcome to the course Environmental Impact Assessment. Water is a necessary component to complete the EIA process. There are legislation guidelines and standards for evaluation. Water is also a supporting factor to many other EIA components, for example, biodiversity, soil, and human health. The standards for water quality and geomorphology are usually set by governments and are regulated by governmental bodies and agencies.

Mostly we see that in many countries, the strictest standards are set for drinking water, as we see by the WHO standard as well as CPCB standards. We also see standards for the regulation of wastewater from domestic and industrial sources. Control can be also placed in the volume of discharge, as well as we see restrictions are often applied on the volume of water, and extraction in specific periods mostly in low flow periods as well as flat standards.

Specific flows may be required in a stream or a river to support aquatic fauna and flora and one method for calculating the requisite flows is the in-stream flow incremental methodology. Other examples are also there like Water Framework Directives WFD, where compliance assessment is to determine if there is likely to be any deterioration of ecological status as a result of development activities based on hydromorphone condition.

Hydromorphone conditions capture the interrelationship between the floral team and the channel parameter. Geomorphological baseline information is common in the EIA process. We also see flood risk assessment to minimize the likelihood of new projects being subjected to flooding and or increasing flooding anywhere else. We see that parallel assessment of these processes is desirable in EIA.

We also note that the World Bank requires EIA of projects proposed for bank financing through its operational policies and Environmental Assessment Sourcebook. Specifically, policy 4 points O 7 is concerned with water resource management. Bank requires study and management of flood control, potable water, sanitation facilities, and water for productive activities in a manner that is economically viable, environmentally sustainable, and socially equitable.

Further World Bank specifies pollution levels and control measures and emission levels acceptable to them, these criteria may vary from country to country. So, focusing on water, we see how important it is. So, today we will look at methods used for EIA specific to the water domain.

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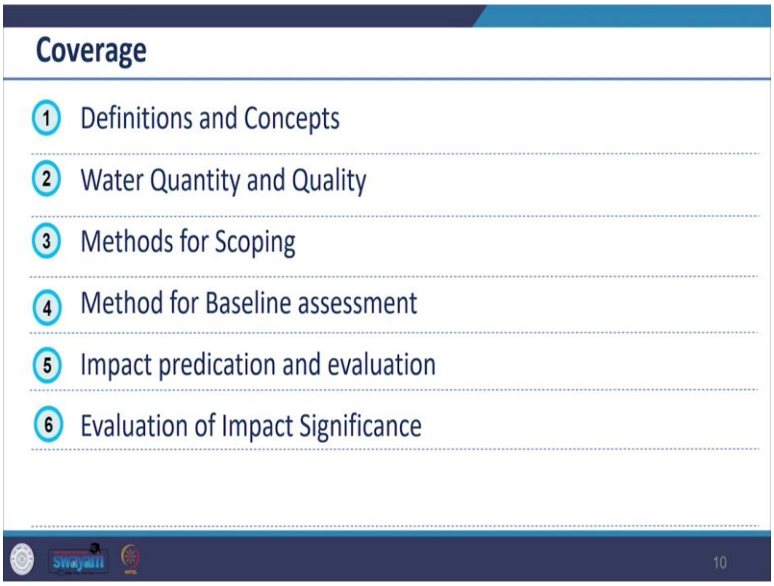

Therefore, today's coverage will include definitions and concepts that will cover water quantity, we will look at the environmental flows, baseline flow, return period, water budget estimation methods, we will look at catchment approach, and parameters for calculating the water budget, we will also look at water quality, fluvial geomorphology, methods for scoping, like a checklist, source pathway receptor model.

We will also look at methods for baseline assessment, as well as we look into impact prediction and evaluation from indirect sources and direct sources, we will also look at different software that are available for the purpose. And finally, we will look at the evaluation of impact significance.

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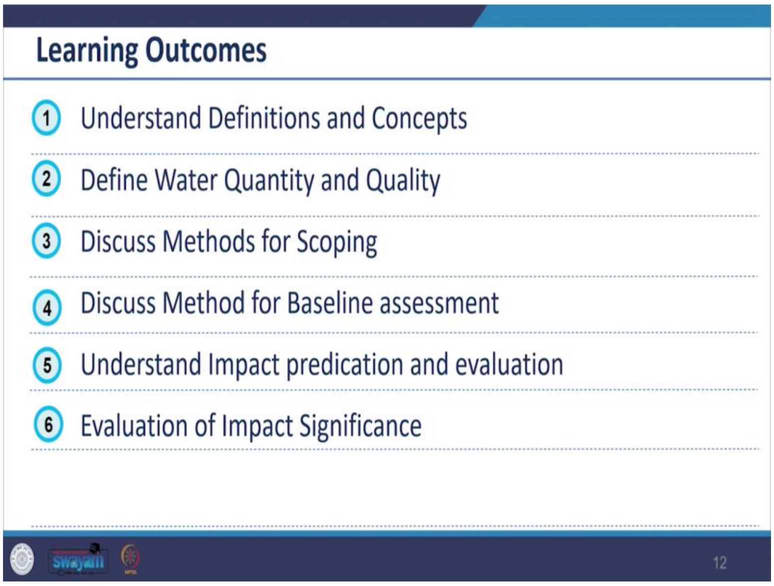

So, accordingly, the expected learning outcomes are that you should be able to define and explain the concepts of what water quantity means, and you should be able to define environmental flows, base flow, return period, and so on. You should be able to define or conceptually explain what water quality means, and what fluvial geomorphology means. You should be able to decide on methods for scoping, and you should be able to identify a checklist and also explain the source pathway receptor model.

You should be able to use the method for baseline assessments and you should be able to identify what kind of data you will require for that. You should be able to identify possible impact prediction and evaluation methods for both indirect sources as well as direct sources, you should be able to list various software, which are available and choose among them. Finally, you should be able to also look at methods for evaluation of impact significance.

For today's session, the key reference will be Chapter Two on water from the book Method on Environmental and Social Impact Assessment, edited by Ricky Terryville and Graham Wood. So, let us begin with some of the key definitions and concepts. Starting with water quantity, when we look at water quantity, we check the water balance in our budget. Water balance or budget for any hydrological system is estimated to predict or take into account various flow pathways, how is water moving and storage components? Where is the water stored in the system? So, we will look at all these aspects when we do the water balance estimation.

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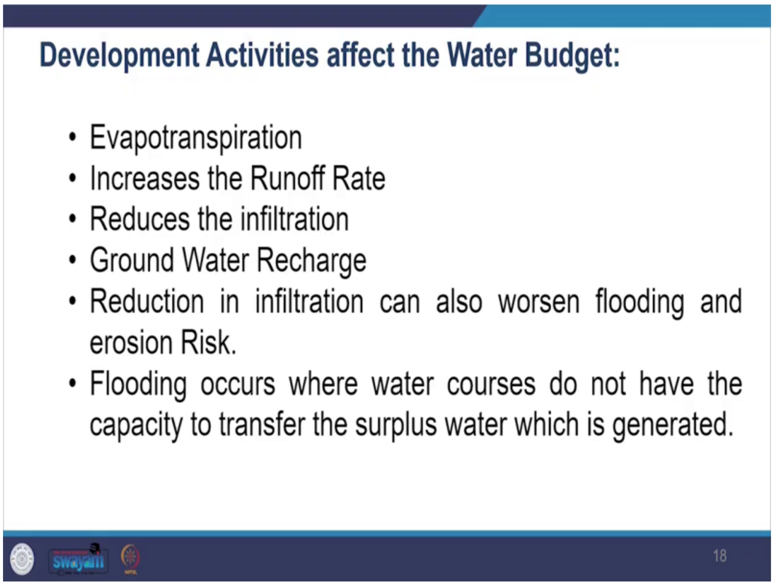

Several developmental activities like what effects that we saw that activities such as when the forest cover is removed for urban development, affect evapotranspiration, it also increases the runoff rate, and reduces the infiltration, meaning impacts the groundwater recharge. It also causes a reduction in infiltration and can also worsen flooding and erosion risk. Flooding occurs when water courses cannot transfer the surplus water that is generated. There are numerous properties at risk in many countries and it has it also has a potential impact on our health and river system.

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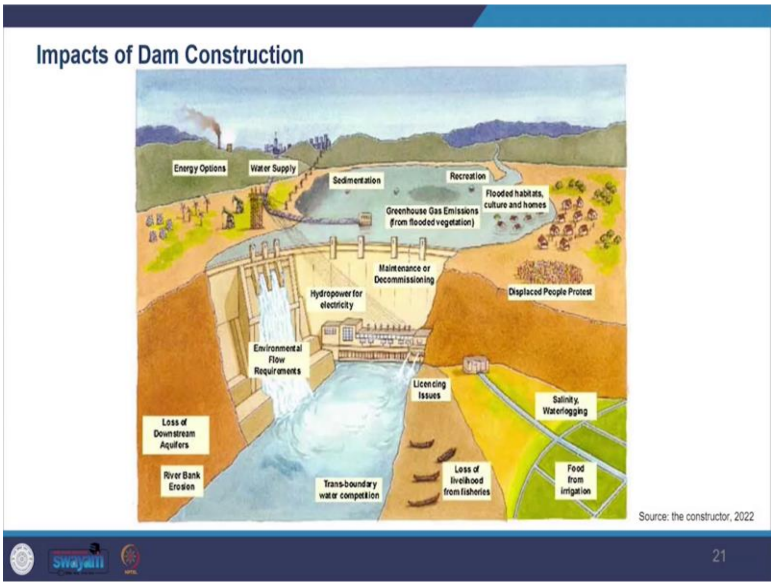

Another example we can talk about is the construction of dams, which affects the flood pulse, meaning the periodic inundation and drought. When we drain wetlands and marshes for development purposes, also we see runoff increases from the land. Furthermore, we see agriculture also increases the runoff. Likewise, we see when we transfer water for domestic purposes housing, the supply we get in our house, our irrigation purpose the quantity changes.

We also change the water balance by drawing water for industry and agriculture purposes and we reduce the flow, this impacts the availability of water downstream of the river and also impacts aquatic ecology and how sediment is transported through the system. Even by discharging wastewater from the treatment plant, we can change the quantities, so, we add to the existing water.

Now, let us see the environmental flow. Environmental flow is the quality, quantity, and timing of water flows required to maintain the components, functions, processes, and residents of aquatic ecosystems providing goods and services to people. And we see that this is increasingly being recognized as an issue and guidelines regarding environmental flows are being established around the world.

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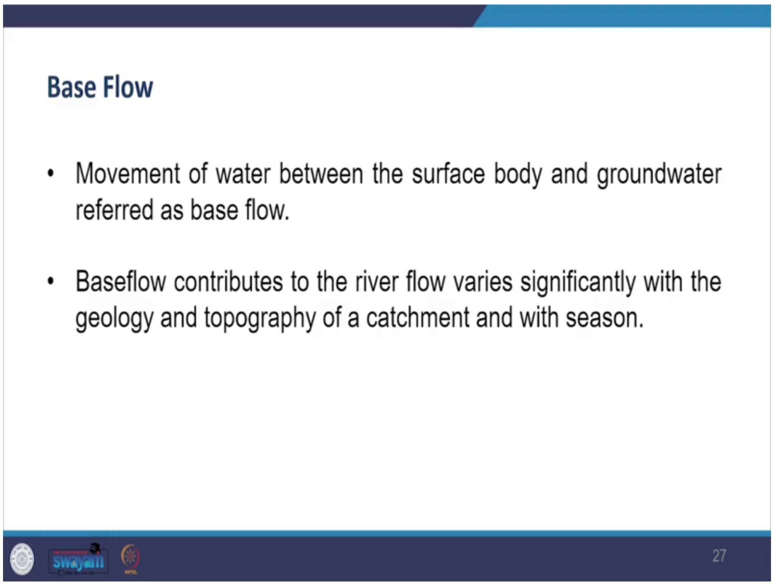

We may also acquaint ourselves with the concept of base flow. Let us see what is base flow. There is a movement of water between the surface body and the groundwater which is referred to as base flow. How much does the base flow contribute to the river flow? Very significantly with the geology and topography of a catchment and it varies with the seasons.

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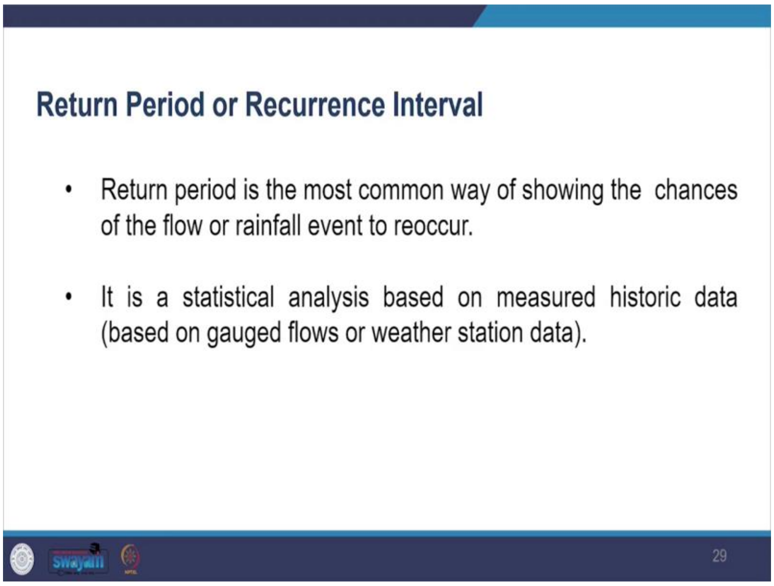

We will also make ourselves aware of the return period, the concept of return period or recurrence interval. The return period is the most common way of showing the chances of the flow or rainfall events to reoccur. It is a statistical analysis based on measured historical data you can see as gauged flows or weather station data.

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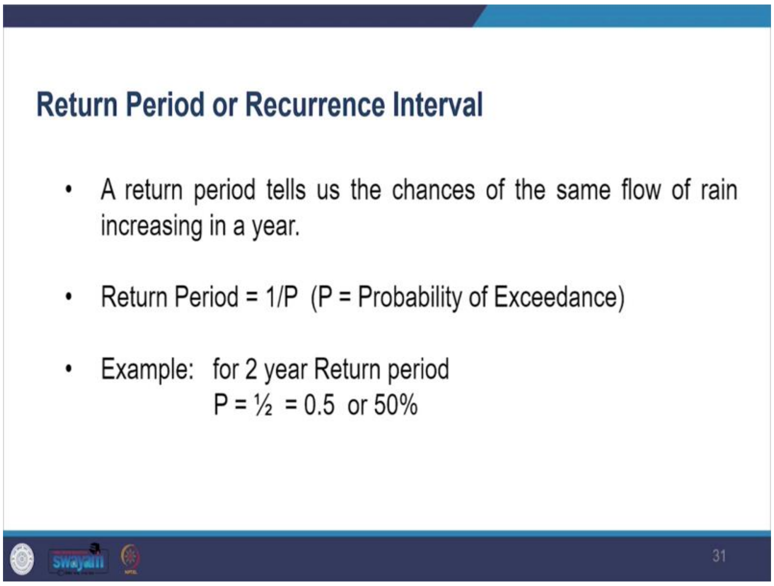

A return period, what does it tell us? It tells us the chances of the same flow of rain increasing in a year. For example, 2 year return period event has a 50 percent chance of being increasing in 1 year. Whereas a 25-year return period event has a 4 percent chance in a year, we see that a 100-year event is usually used for flood risk mapping.

For the environmental assessment purpose, the proponents have to establish that the development which is being done whatever they are proposing will not increase the likelihood of a particular return period event and therefore, will not increase flood risk to the properties downstream. So, they have to establish that the return period flows can also be used for channel designs and in low-flow assessments.

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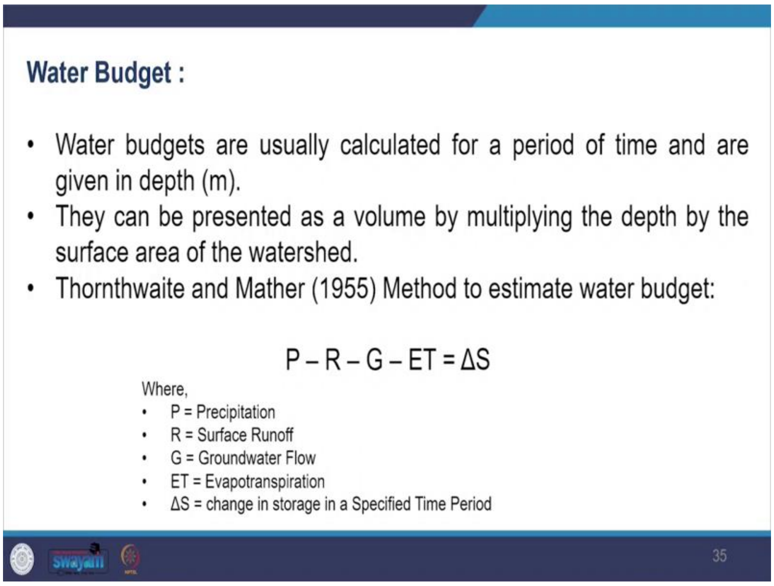

Now, moving on to estimating the water budget, water budgets are usually calculated for some time and are given in-depth in meters, they can be presented as a volume by multiplying the depth by the surface area of the watershed.

A commonly used method to estimate water budget is given by Thornthwaite and Mather, which is precipitation, subtracting surface runoff, subtracting groundwater flow, and subtracting evapotranspiration, which gives the change in storage in a specified period. We also see a catchment approach.

So, another approach we see for calculating is also called as drainage basin approach. In this approach, catchments are separated by a watershed boundary, which is a natural division line along the highest points of land, precipitation that is rain, snow, and so on. Falling into the area of the catchment eventually reaches the same river, there may be evaporation or infiltration during the movement.

Catchments can be divided into sub-catchments also along lines of elevations and they may vary widely according to the size and surface water and groundwater it holds, so, there can be variations in that as well. How the water moves in a hydrological cycle, would vary as per the time and location. So, how is water moving, it can be different for different locations, they the way water moves can cause surplus water and also cause a rise in water levels and maybe cause potential flooding or it may also lead to a deficit of water potentially leading to drought conditions, so, you see the implications.

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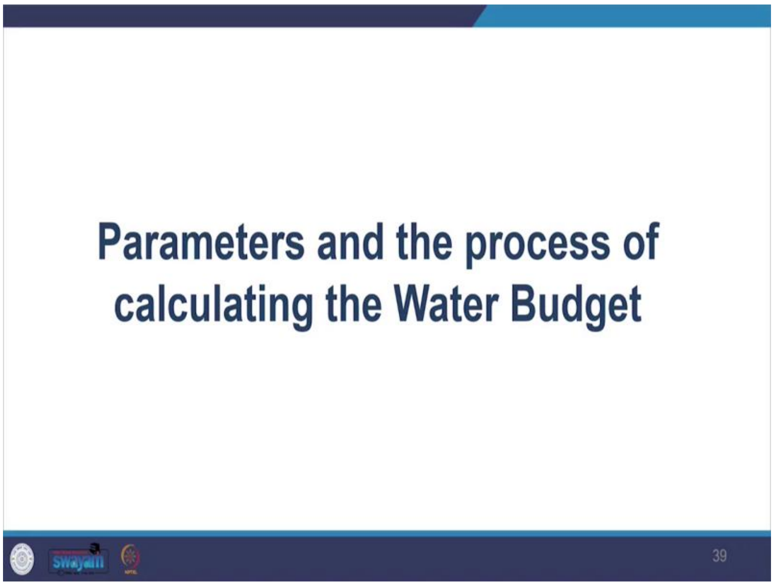

Let us see the parameters and the process of calculating the water budget, where and how do we get data information? And we are looking at the available information here.

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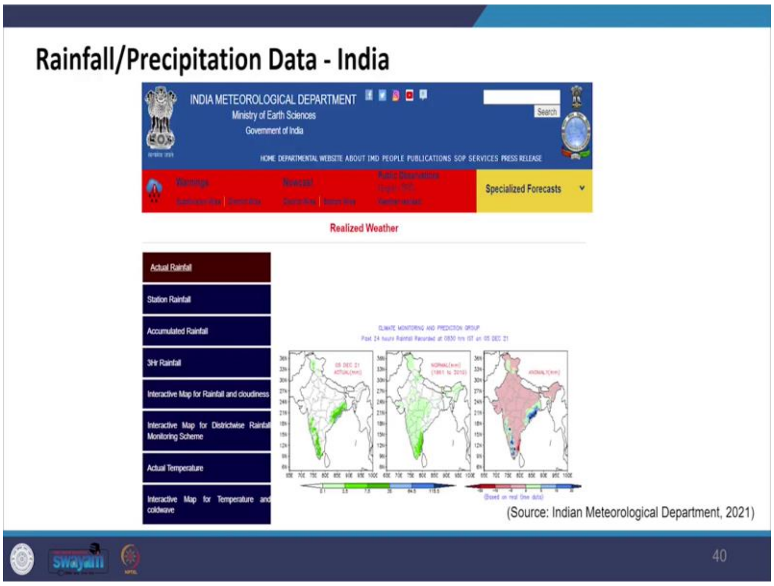

Let us see the parameters and the process of calculating the water budget and see what kind of information is required. First, we see precipitation, we see that the rain, snow sleet, or hail that falls to or condenses on the ground, which is referred to as precipitation is the main input to the hydrological cycle. Usually, precipitation data is used to evaluate the long-term effects of a project for a normal year.

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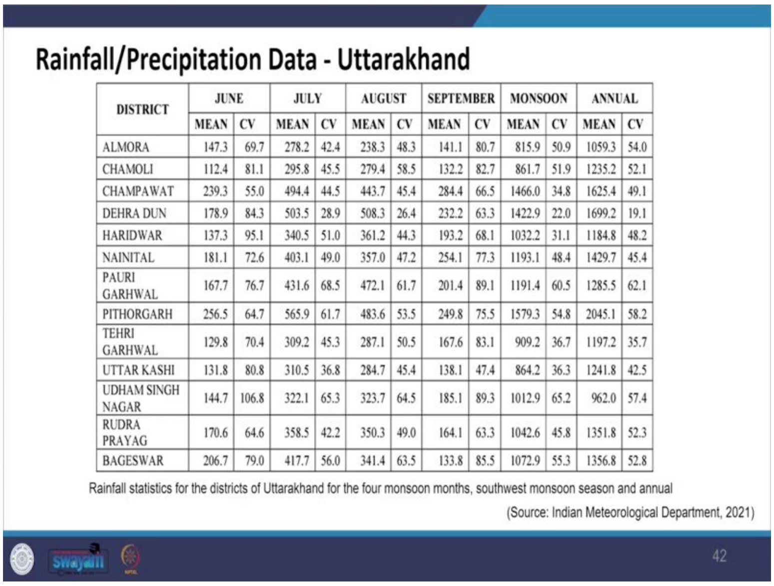

Rainfall/Precipitation Data - Uttarakhand

DISTRICT	JUNE		JULY		AUGUST		SEPTEMBER		MONSOON		ANNUAL	
	MEAN	CV	MEAN	CV	MEAN	CV	MEAN	CV	MEAN	CV	MEAN	CV
ALMORA	147.3	69.7	278.2	42.4	238.3	48.3	141.1	80.7	815.9	50.9	1059.3	54.0
CHAMOLI	112.4	81.1	295.8	45.5	279.4	58.5	132.2	82.7	861.7	51.9	1235.2	52.1
CHAMPAWAT	239.3	55.0	494.4	44.5	443.7	45.4	284.4	66.5	1466.0	34.8	1625.4	49.1
DEHRA DUN	178.9	84.3	503.5	28.9	508.3	26.4	232.2	63.3	1422.9	22.0	1699.2	19.1
HARIDWAR	137.3	95.1	340.5	51.0	361.2	44.3	193.2	68.1	1032.2	31.1	1184.8	48.2
NAINITAL	181.1	72.6	403.1	49.0	357.0	47.2	254.1	77.3	1193.1	48.4	1429.7	45.4
PAURI GARHWAL	167.7	76.7	431.6	68.5	472.1	61.7	201.4	89.1	1191.4	60.5	1285.5	62.1
PITHORGARH	256.5	64.7	565.9	61.7	483.6	53.5	249.8	75.5	1579.3	54.8	2045.1	58.2
TEHRI GARHWAL	129.8	70.4	309.2	45.3	287.1	50.5	167.6	83.1	909.2	36.7	1197.2	35.7
UTTAR KASHI	131.8	80.8	310.5	36.8	284.7	45.4	138.1	47.4	864.2	36.3	1241.8	42.5
UDHAM SINGH NAGAR	144.7	106.8	322.1	65.3	323.7	64.5	185.1	89.3	1012.9	65.2	962.0	57.4
RUDRA PRAYAG	170.6	64.6	358.5	42.2	350.3	49.0	164.1	63.3	1042.6	45.8	1351.8	52.3
BAGESWAR	206.7	79.0	417.7	56.0	341.4	63.5	133.8	85.5	1072.9	55.3	1356.8	52.8

Rainfall statistics for the districts of Uttarakhand for the four monsoon months, southwest monsoon season and annual

(Source: Indian Meteorological Department, 2021)

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Data as suggested should ideally be tabulated by month, possibly using that you can use Excel spreadsheet for the purpose.

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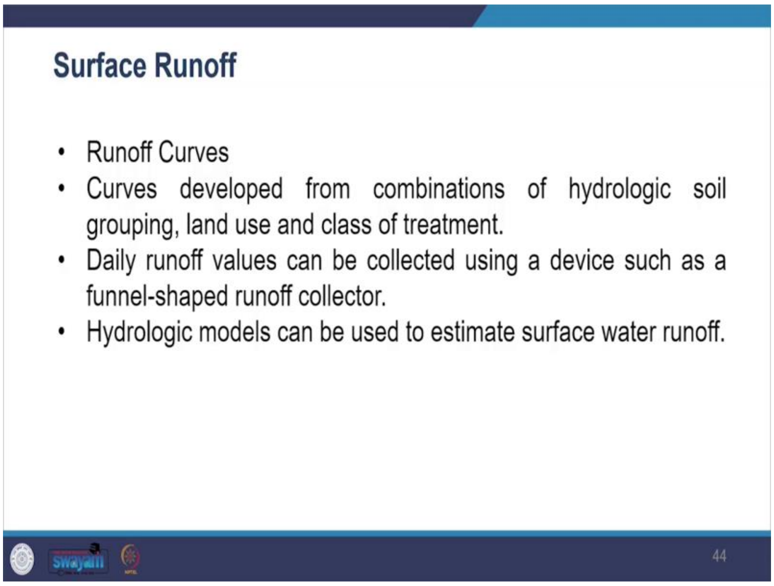

Another parameter we see is surface runoff. Surface runoff can be estimated from runoff curves. The curves were developed from a combination of hydrologic soil grouping, land use, and class of treatment. Daily runoff values can be collected using a device such as a funnel-shaped runoff collector for detailed assessment requiring more accurate results, hydrologic models can be used to estimate surface water runoff. We will see some of the software which are available for the purpose.

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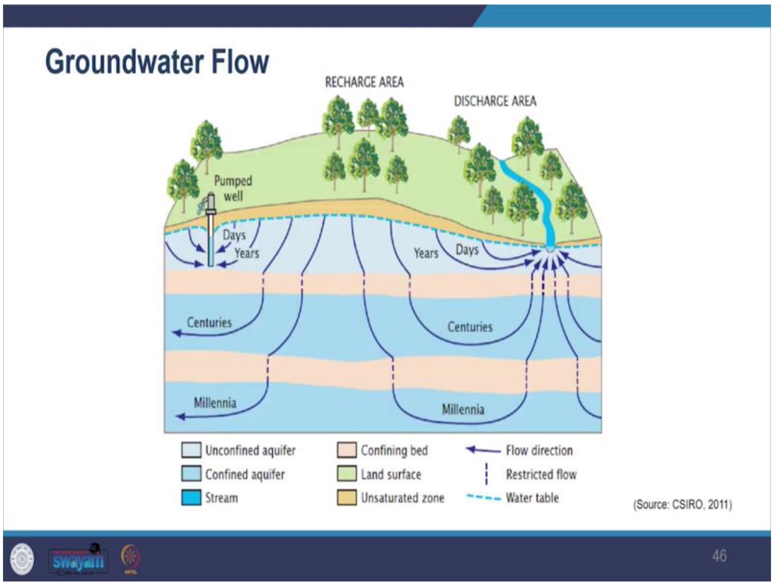

Another parameter we see is groundwater flow. The distribution of the hydraulic head, hydraulic head which is the mechanical energy state through an aquifer dictates where groundwater will flow. So, the hydraulic head dictates determines where and how the groundwater will flow for unconfined aquifers. Let us see what is unconfined aquifers, unconfined aquifers are those where water seeps from the ground surface directly above the aquifer. For unconfined aquifers, the hydraulic head is the water table itself.

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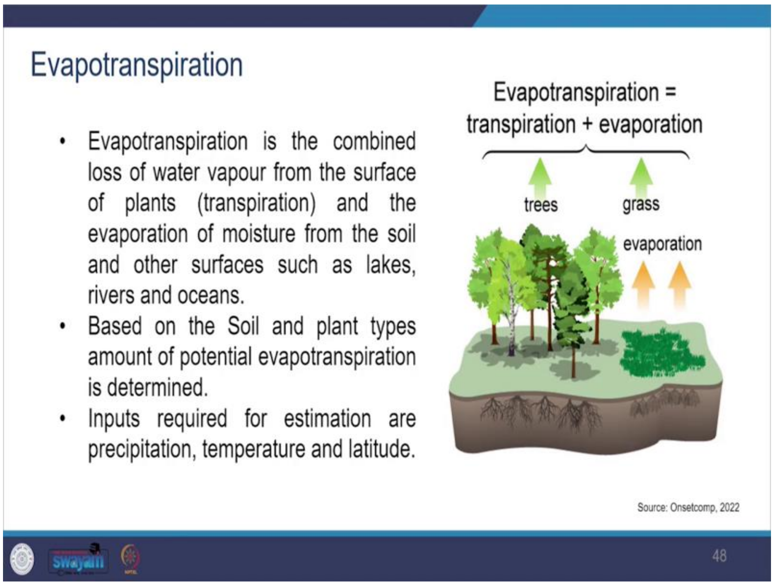

Looking at another factor, looking at another factor evapotranspiration, evapotranspiration is the combined loss of water vapor from the surface of plants through transpiration and evaporation of moisture from the soil and other surfaces such as lakes, water lakes, rivers, and oceans. Based on the soil and plant types, the amount of potential evapotranspiration is determined, so, you can estimate that. There are methods for estimating actual evapotranspiration inputs required for estimation, we see precipitation, temperature, and latitude are key for the purpose.

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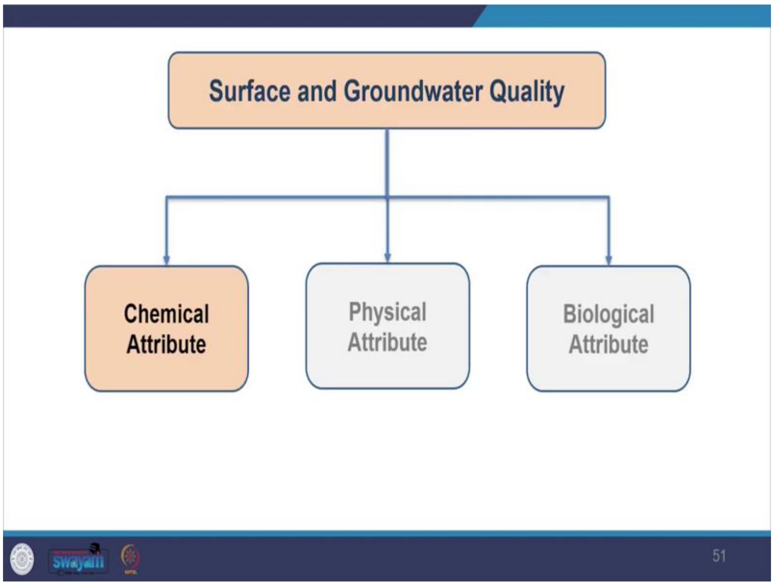

So, moving on now, let us look at the concept of water quality, surface and groundwater quality is determined by assessing three classes of attributes. Surface and groundwater quality is determined by assessing three classes of attributes first, the chemical attribute, the dissolved chemical solutes, which originate from atmosphere soil or weathering of bedrock, we need to understand that the water is never pure.

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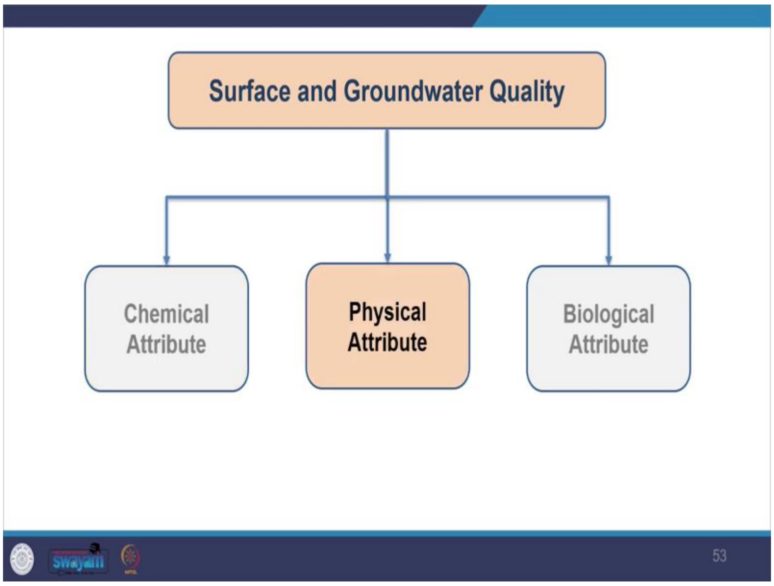

Second, regarding the physical properties we see that natural waters vary in the amount of particulate material present in them, rivers typically carry large quantities of particulates. We can also see the term here bedload, bedload is the riverbed particulates, these particulates range in size such as they could be sled cells, core sand, gravels, or even boulders. These bedload materials can move when the flow of water exceeds the threshold limit, the flow of water depends on both the channel's slope and discharge.

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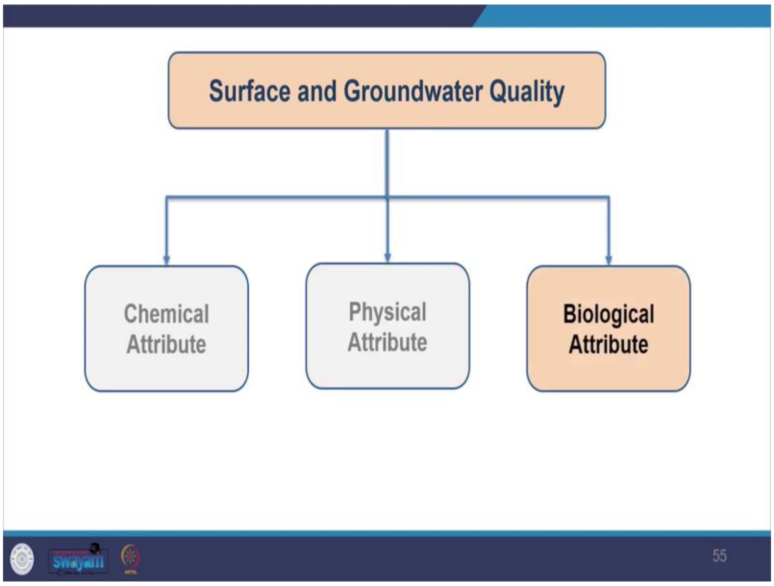

Third, the biological attribute, biological water characteristics are used to describe the presence of micro-biological organisms and waterborne pathogens, many of these can cause health issues for humans and animals. These can enter water bodies either naturally or through the release of untreated or partially treated sewage, pollution can also happen and pollution can happen from point source or nonpoint source.

We see what impact happens on the receiving water, so that just does not depend on the development activities itself, but also depends on the water quality. So, how is the receiving agent in the quality of that also affects the impact of the development activities? For example, you may think of pollutants being released in the flowing water like rivers compared to pollution being pollutants being disposed in distilled water such as lakes. So, we see that many countries have set standards for each of these attributes.

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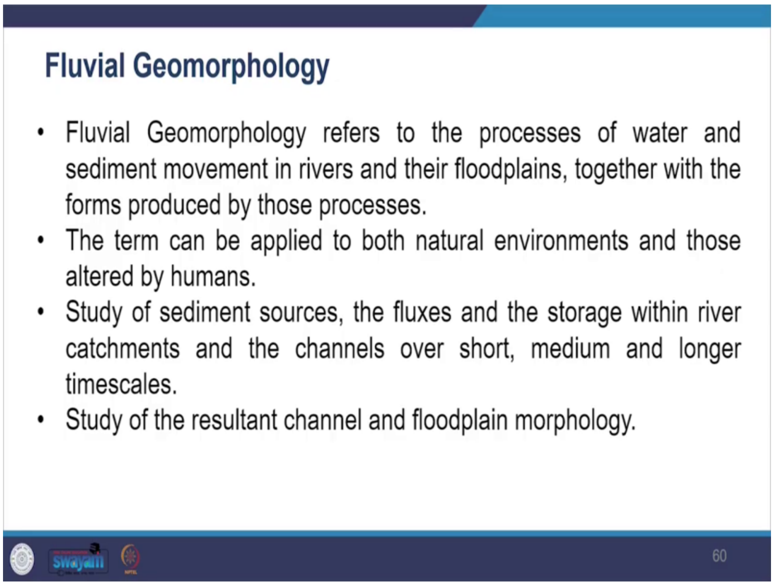

Now, moving on, let us try to understand the fluvial geomorphology. When we cover fluvial geomorphology, we refer to the process of water and sediment movement in rivers and their floodplains together with the forms produced by those processes. The term can be applied to both natural environments and those altered by humans. In this, we study the sediment sources, the fluxes, and the storage within river catchments and the channels over short, medium, and longer timescales.

We also study the resultant channel and floodplain morphology in the process. This understanding is essential to do assessment and design of sustainable fluvial projects. We also find the term hydro morphology that covers a larger aspect of fluvial geomorphology and also emphasizes impact assessment as well as mitigation.

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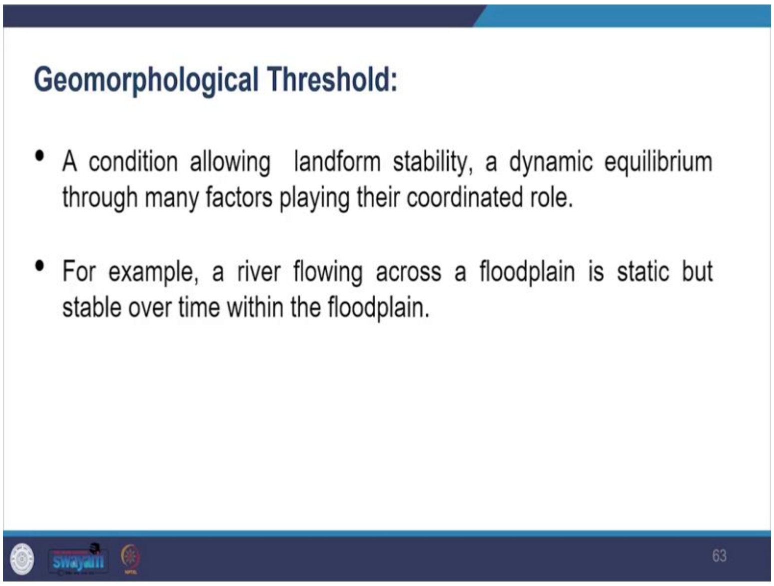

It is important to understand the concept of geomorphological threshold, geomorphological threshold is a condition allowing landforms stability, a dynamic equilibrium, the stability is an equilibrium which is attained among many factors playing a coordinated role. For example, a river flowing across the floodplain looks static, it is not static, but it is stable all works in harmony.

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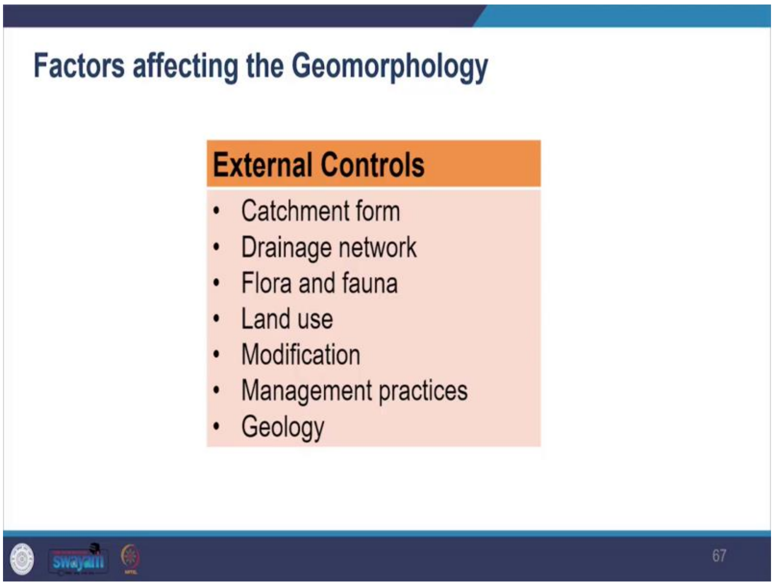

There can be several external and internal controls that affect the geomorphology of a river channel or a floodplain, you may pay attention to the external controls and the internal controls, there will be changes in these due to the proposed development.

So, whatever you develop might change it, you can see that the external controls are like catchment form, drainage network, flora and fauna, land use, modification, management practice, and geology.

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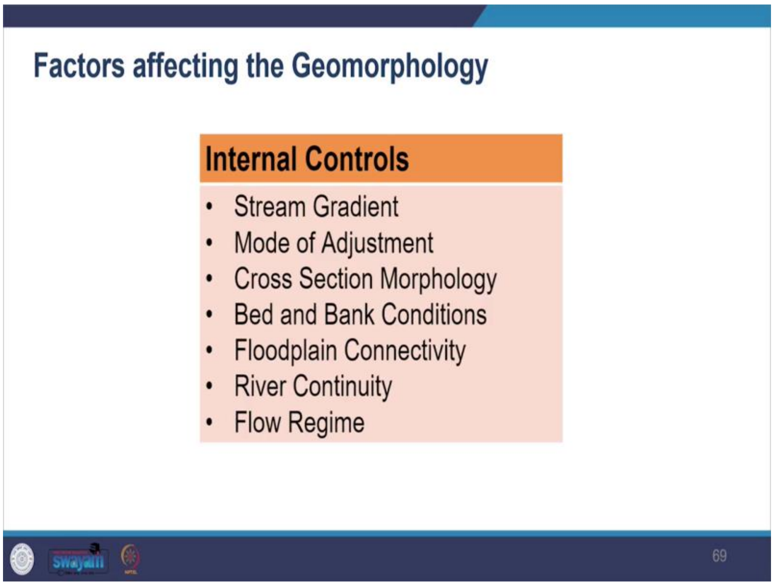

Likewise, you can see internal controls like stream gradients, mode of adjustment, cross-sectional morphology, and bed and bank condition.

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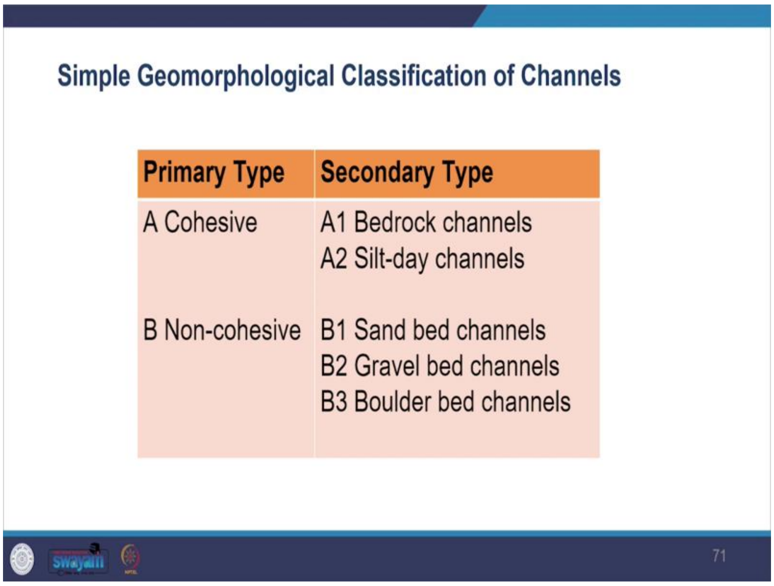

We can also learn about simple geomorphological classification of channels based on cohesiveness. There are other classifications too, however, river types vary widely and have an impact on mitigation solutions applicable in one geography whatever we see here may be appropriate for another. So, it has to be very much contextual. So, you can see there is a range of types here the cohesive and non-cohesive you can see the bedrock channels, Silt-day channels, and so on.

We may note that geomorphology is a specialist discipline typically requiring a specialist consultant to undertake during EIA. So, the consultant would take care of all the details and be able to give inputs on this process.

Moving on we will see the first stage of the EIA process scoping while undertaking assessment underwater. We may recollect that the scoping stage involves determining the types of activities likely to be involved in development from construction, through operation to decommissioning of the project, if it is relevant, the duration of each of these stages, and any alternatives considered.

We must have a very clear understanding of how the proposed project will be operated given the local conditions and all that is all of these is required at this stage for early identification of potential impact and it will be based on the professional judgments informed through the qualitative resources from the references you have.

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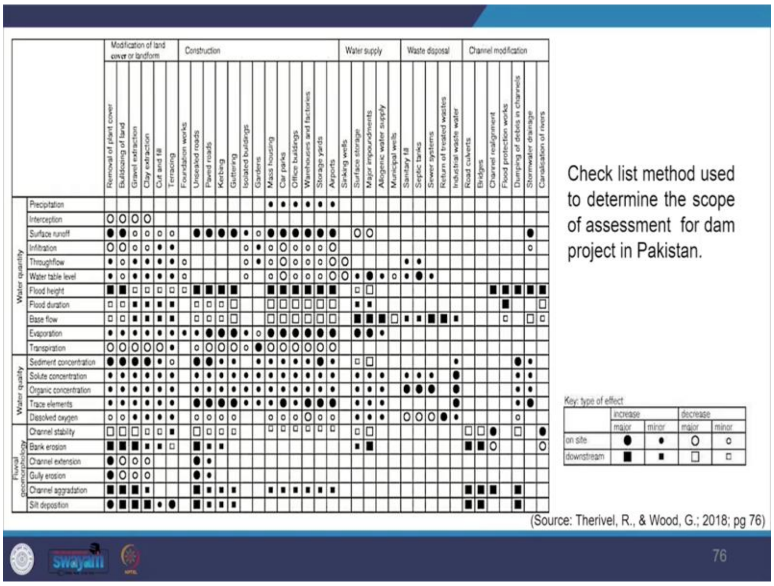

Here we see a checklist method used to determine the scope of assessment of for dam project in Pakistan. We have now developed a considerable understanding of the impact of dam development during operational as well as construction phases. Water-related impacts of dam operations are usually very extensive ranging from water quantity, quality, and fluvial geomorphological study. So, you can see the checklist here.

We also find scoping checklists for potential water-related operational impact with particular reference to dam schemes. Checklists are simple methods used in many stages of EIA. So, we are just looking at this particular stage.

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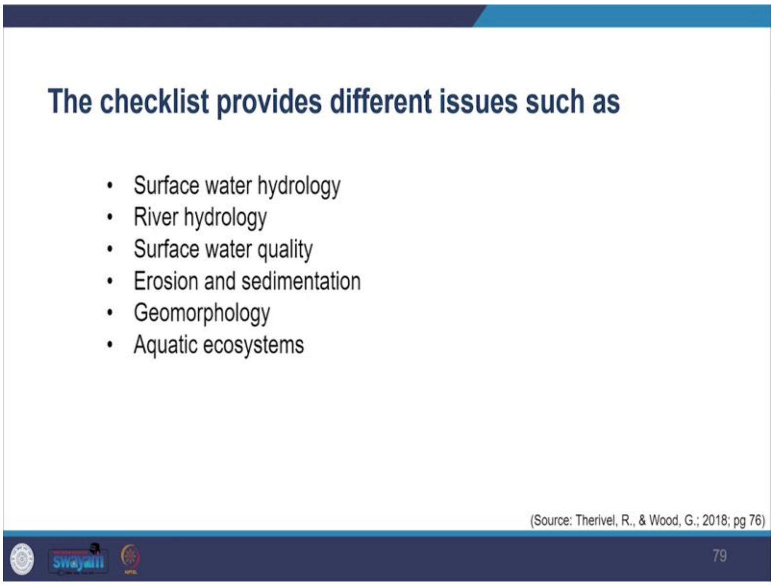

The checklist provides different issues such as surface water hydrology, river hydrology, surface water quality, erosion and sedimentation, geomorphology, and aquatic ecosystems.

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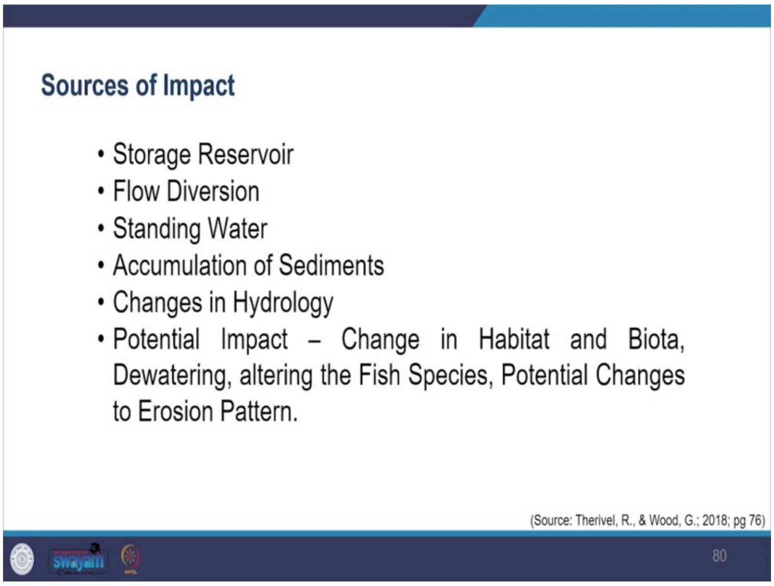

And it provides sources of impact such as storage reservoir, flow divergence or whatever you do in the dam, standing water which will be there, accumulation of sedimentation changes accumulation of sediments, changes in hydrology and it also provides the potential impacts such as change in habitat and biota, dewatering, altering the fish species potential changes in erosion pattern.

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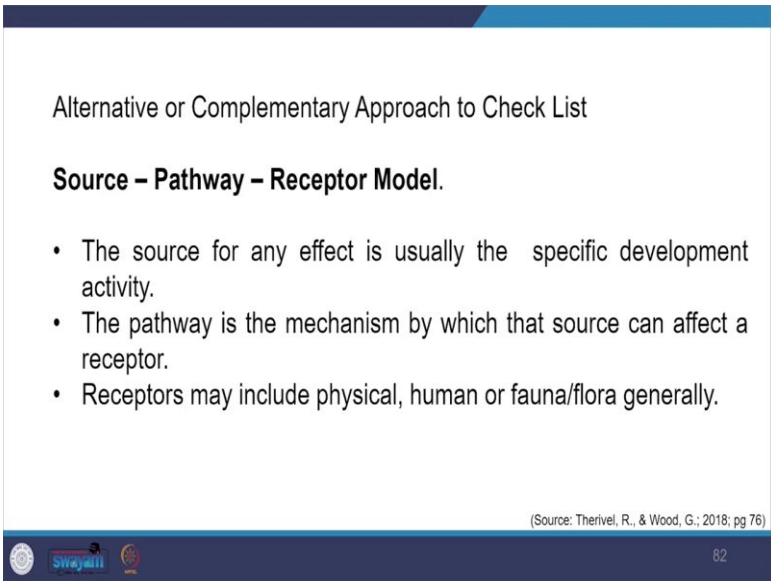

The checklist is provided to you in the reading. We also see an alternative or complementary approach to the checklist. So, you see this method you have a source pathway receptor model, the source for any effect is usually the specific development activity. The pathway that we see here is the mechanism by which the source can affect a receptor, such as via hydraulic effects and the receptor may include it could be anybody, it could be physical, human flora or fauna. A watercourse can then be considered as a pathway and as a receptor as well.

Potential physical effects on the water environments from development may include river channel modification. So, the river channel can be modified from activities like dredging, navigation, maintenance, and elimination of freshwater lakes by the development buildings of a new dam, which leads to the loss of water bodies and downstream impacts on water and sediment discharge. We can also see discontinuance of the dam or we have with potential to cause erosion and lead to sediments being released downstream.

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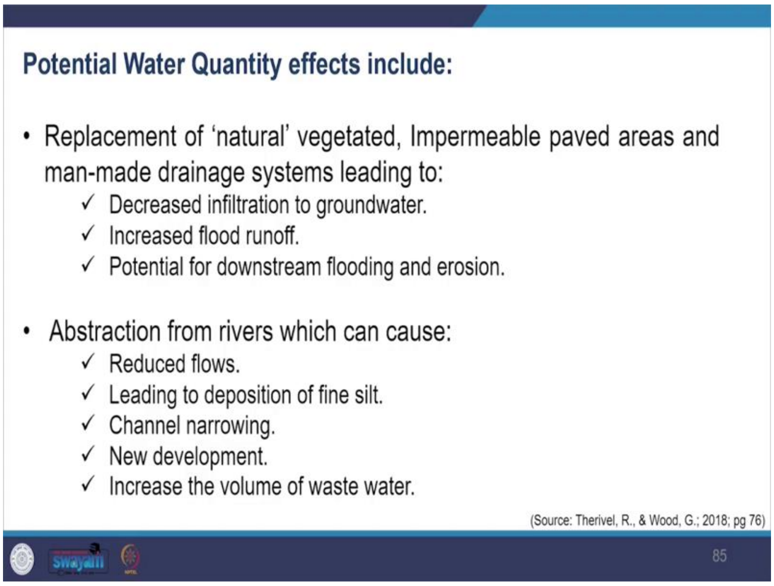

Potential water quantity effects include replacements of natural vegetation. We might get more impermeable paved areas and we can the effects could include manmade drainage systems leading to decreased infiltration to groundwater and so on. Further, we also see abstraction from rivers which can cause reduced flow leading to the deposition of fine silt. In some cases, channel narrowing is a new development that can increase the burden on the water supply and increase the volume of wastewater as well.

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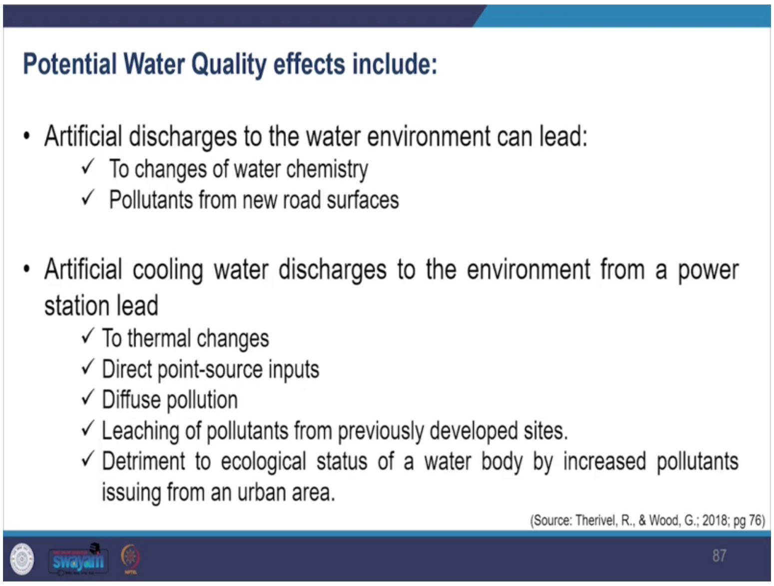

We also see potential water quality effects include artificial discharge, pollutants from new road surfaces, and artificial cooling water discharge to the environment from a power station leading to thermal changes.

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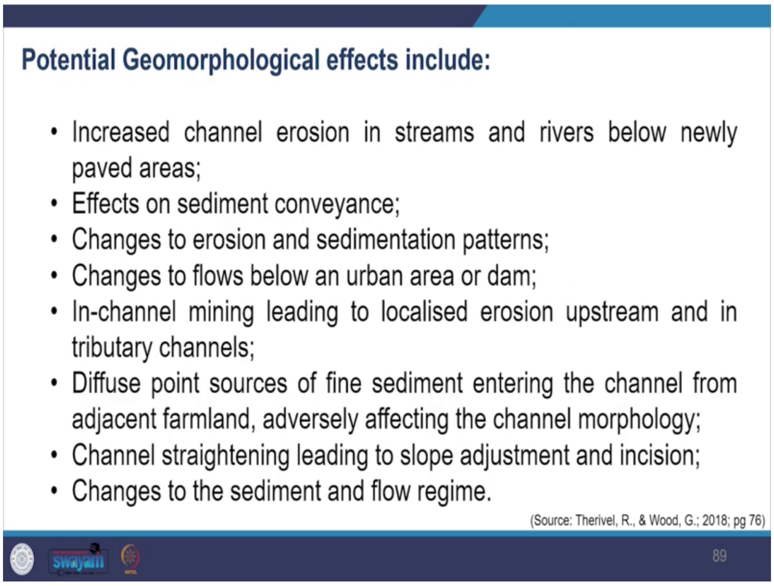

We also see potential geomorphological effects including increased channel erosion in streamline, changes to erosion in sedimentation pattern, and changes to flows below an urban area or dam, affecting the morphology of a channel. In-channel mining, leads to localized erosion upstream and in tributary channels, diffuse point sources of fine sediments, entering the channels from adjacent farmland, and so on.

Moving on to the next stage of assessments, which is baseline assessment, the stage this particular stage involves describing existing baseline conditions for water quantity, water quality, and fluvial geomorphology for the area potentially impacted by a project. Typically, different data collection standards apply to different countries, so, in whichever country you are practicing or preparing EIA and professional judgments are key to this. And again, you have to use expert consultants, which is often recommended.

Collection of field data for the hydrological parameter can be very difficult and it can be time-consuming as well and it requires sampling over an extended period, resources and time constraints would also determine what method you use. Water quantity assessment required both desktop and field study.

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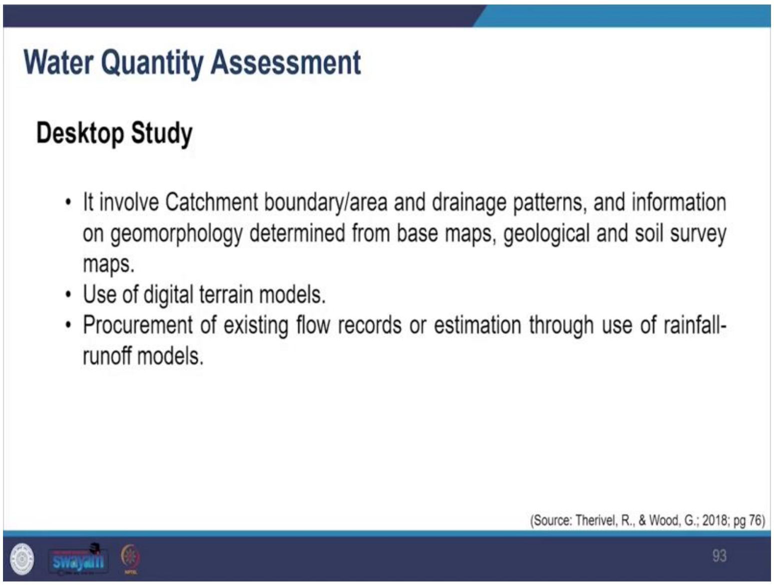

The desktop study will involve catchment boundary area and drainage pattern, and information on geomorphology such as slopes geology, soil, and land use, which can be determined from the base maps, geological, and soil survey maps. We also see the use of digital terrain models. You can also procure existing flow records or estimations through the use of rainfall-runoff models, the limits of rain, and river floodplain, maybe already be there, based on the topographic and hydraulic modeling.

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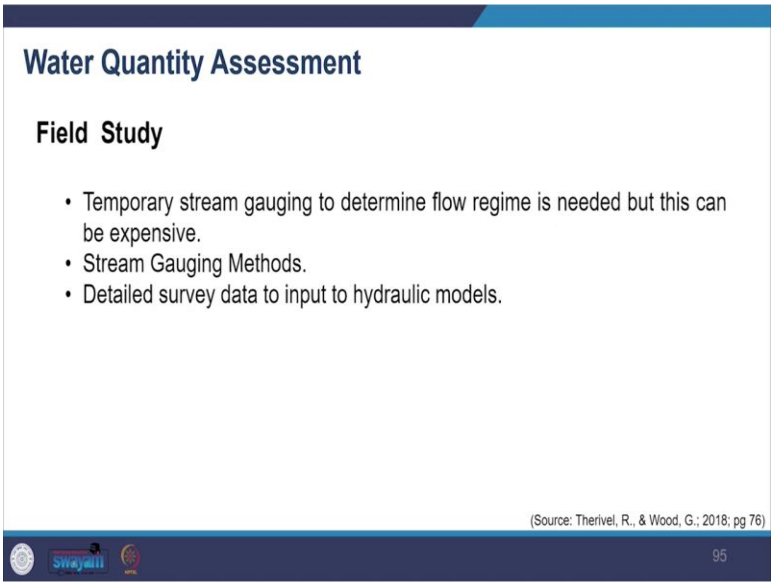

In this case, quantity field study involves temporary stream gauging to determine the flow regime for high flows and low flows. It is usually needed but this can be very expensive. So, most of the secondary data is used for this purpose. If an assessment is needed of the length of the river this is normally divided into regions, sections are fairly uniform morphometry and flows, and detailed survey data to input into the hydraulic model all these are done through the field survey.

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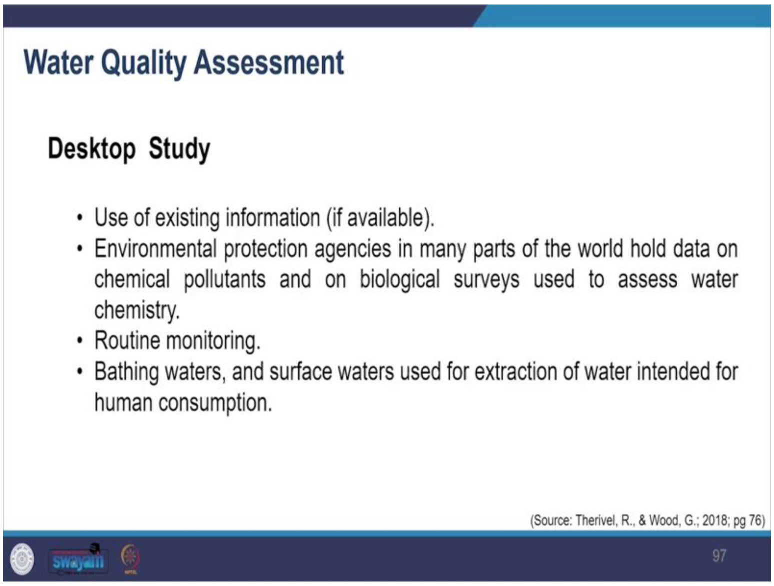

Further, we see for water quality, in this through the desktop study, use of existing information, if it is available, is taken, routine monitoring may be available for such purpose, so that can be taken the pollution level in the water, those readings can be taken here.

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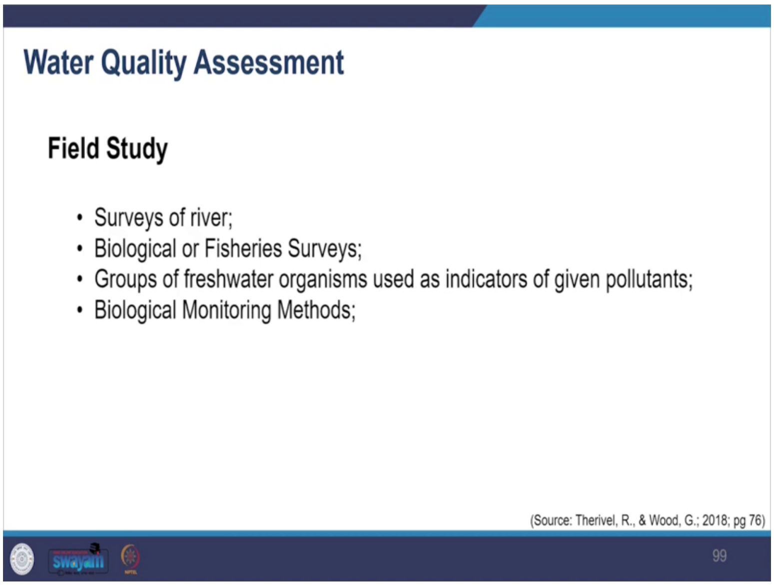

For this the field survey would include the river chemistry, however, that is very expensive and given the cost and time it has limited values, it can be taken from the secondary data. And then biological or fishery surveys are considered to be more valuable because they give a reliable indication of the long-term health of the water environment. Most groups of freshwater organisms have been used as indicators of given pollutants.

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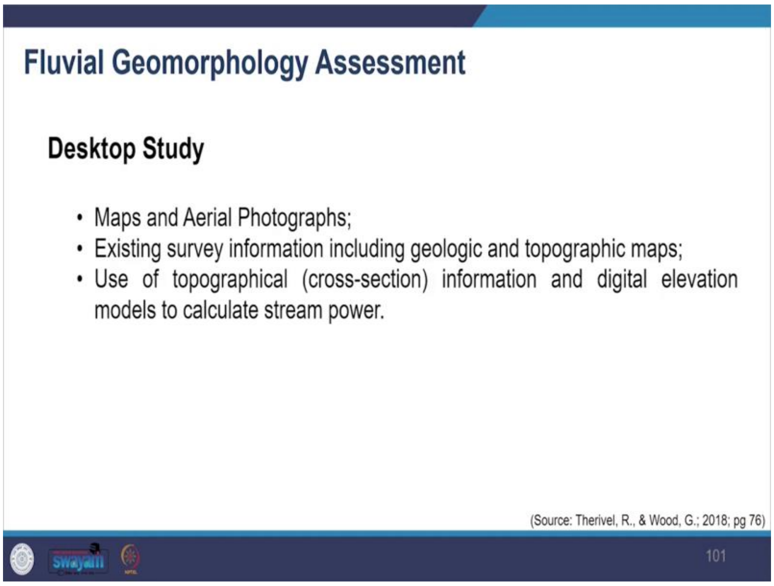

Now, looking at fluvial geomorphology the desktop study would involve channel change over time, which is determined from historic and contemporary maps and aerial photographs using GIS overlay if that is possible, the desktop study would also be comprised of survey information including geologic and topographic maps. We also see the use of topographical information and digital elevation models to calculate stream power.

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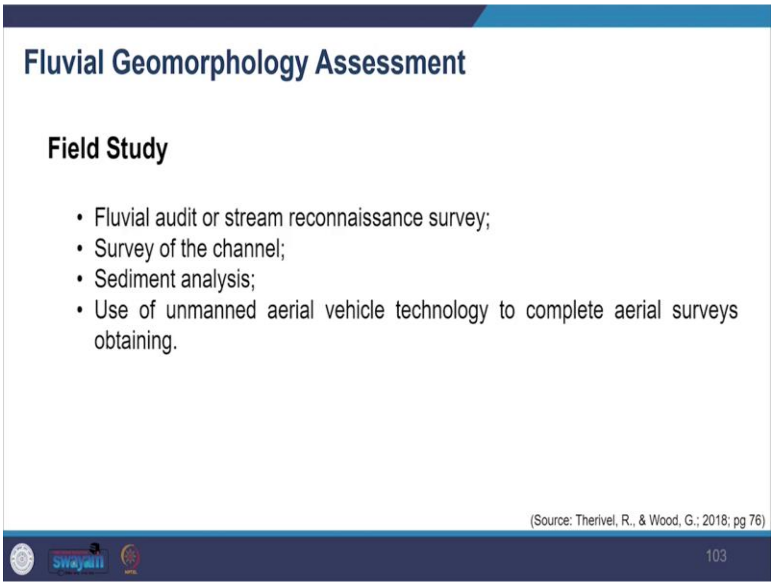

The field study in this particular case would involve a stream reconnaissance survey to collect information on channel size. Survey of the channel to obtain accurate slope and bank full characteristics and to record geomorphological features. Sediment analysis might also help increase the use of unmanned aerial vehicle technology like drones and etcetera can also be used here.

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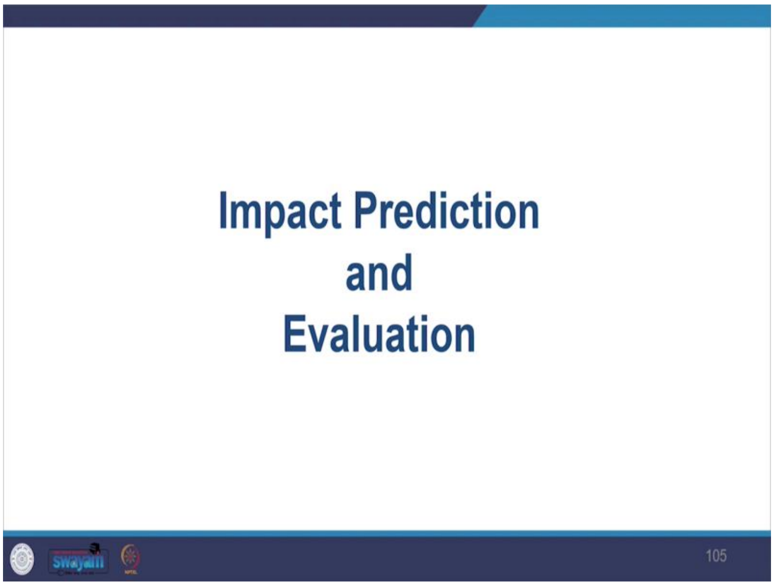

Moving to the next stage of impact prediction and evaluation, we see potential direct impacts on water environments arising from different development activities. And you may note that local data and information are key for the purpose and also expert judgment is required to contextualize your studies.

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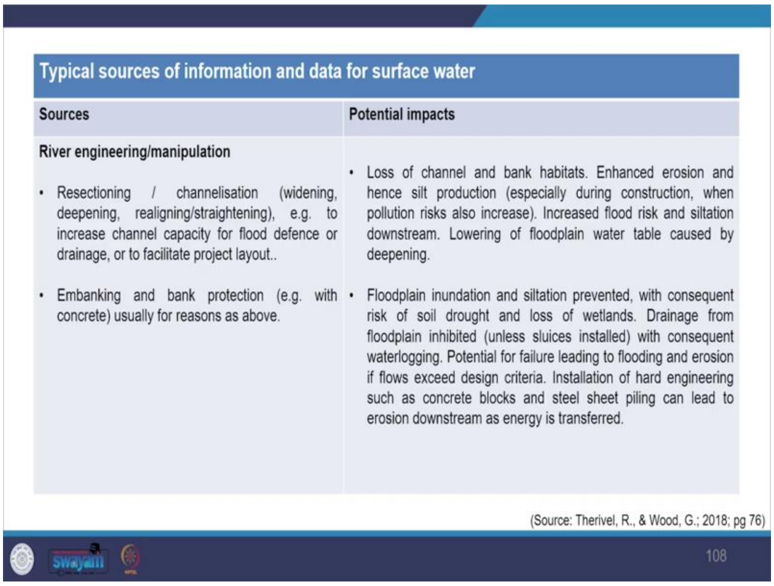

For example, the sources for indirect could be river engineering manipulation such as widening of the river, deepening or realigning, and so on, and banking and bank protection. So, these could be the sources of impact.

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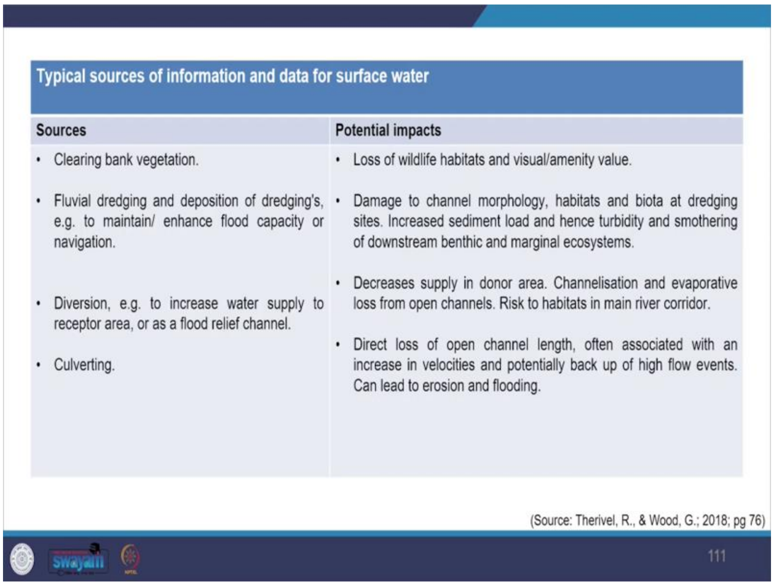

Another direct source example could include clearing bank vegetation, fluvial, dredging and deposition of dredging, diversion, culverting, and so on. And then the potential impact would include loss of wildlife habitat and visual amenity value, damage to channel morphology, decreased supply in the donor area, direct loss of open channel length, and so on. So, we see likewise, that the development of the river floodplain is another direct source.

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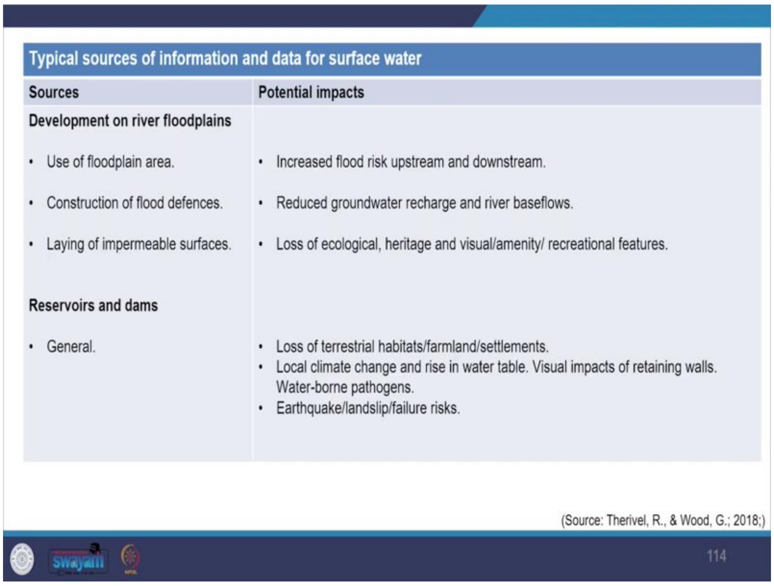

It would also have several impacts like increased flood risk upstream and downstream, reduced groundwater recharge, and river-based flows. Other direct sources include reservoirs and dams on streams, and dams about dam siltation.

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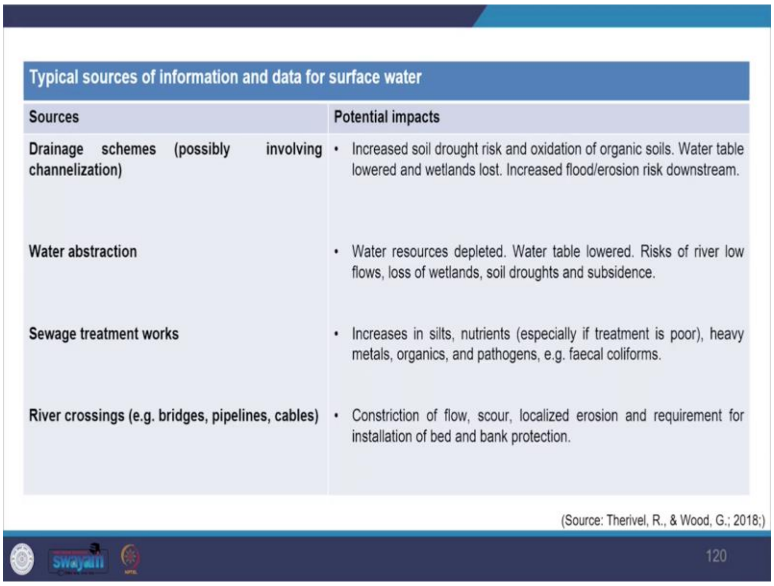

The impact includes loss of river section changes in the flow regime. Another one we saw was mostly in the urban planning domain, which is the drainage schemes possibly involving channelization for withdrawing water, sewage treatment work, and river crossing bridges, pipelines, and cables. So, this also has the possible impact of increasing soil drought risk, oxidation of organic soils, water table lowering, wetlands, and loss of wetlands.

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Indirect source of impact on water

Sources	Potential impacts
Mineral extraction	• Operation phase – Removal/realignment of watercourses. • Loss of floodplain storage/flow capacity. • Drawdown and reduced local streamflows caused by dewatering for dry extraction, or increased runoff from process wash water or extraction methods involving water use. • Increased siltation and chemical pollution downstream, e.g. from spoil heaps/ vehicles/ machinery/ stores. Restoration/aftercare phase – see landfill.

(Source: Therivel, R., & Wood, G.; 2018;)

Indirect source of impact on water

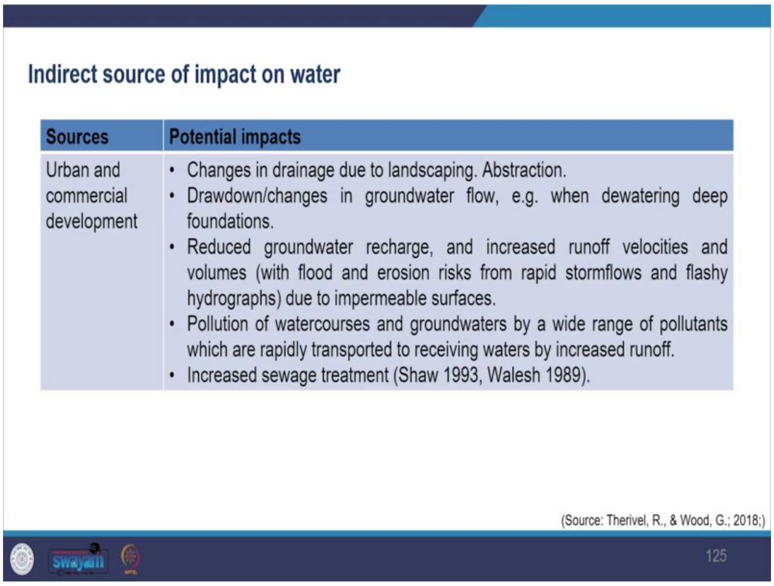
Sources	Potential impacts
Landfill	• Increased runoff from raised landforms, especially if clay-capped. • Reduced groundwater recharge and river baseflows if clay sealed. • Pollution of groundwater and near-surface runoff by leachates and by fertilisers and pesticides from restored grassland.
Forestry and deforestation	• Reduced evapotranspiration and infiltration after felling, with consequent (a) decreased groundwater recharge, (b) increases in runoff, soil erosion, stream-sediment loads and siltation. • Pollution by pesticides, especially herbicides used to prevent re-growth after clear felling.
Intensive agriculture	• Increased runoff and erosion from bare soils. • Drainage or irrigation impacts. • Pollution of surface and groundwaters.

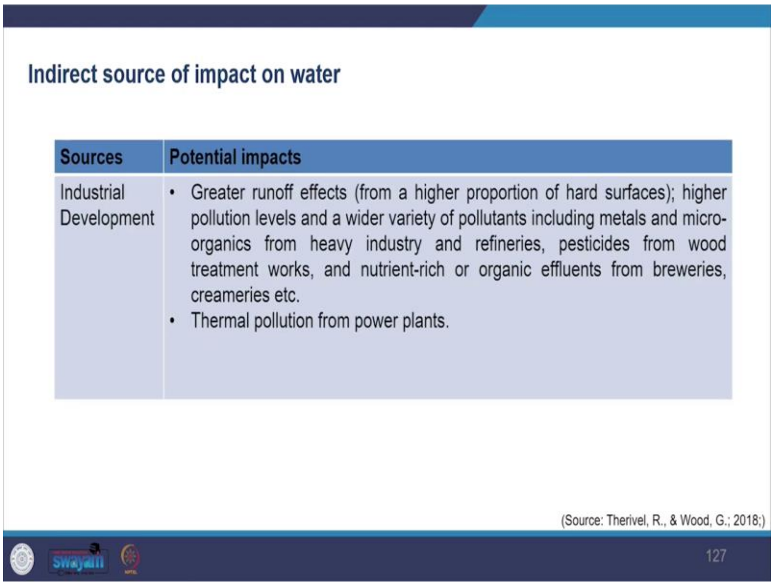
(Source: Therivel, R., & Wood, G.; 2018;)

Indirect source of impact on water

Sources	Potential impacts
Roads	• Changes in drainage systems, e.g. due to gradient changes, bridges, embankments, channel diversion or resectioning. • Drawdown by dewatering when deep cutting. Increased runoff from impermeable surfaces, with risks of flash floods and erosion. • Increased sediment loads from vehicles, road wear, and erosion of cuttings and embankments. • Pollution of watercourses by organic content of silt, other organics (e.g. oils, bitumen, rubber), de-icing salt (and impurities), metals (mainly vehicle corrosion), plant nutrients and pesticides from verge maintenance, and accidental spillages of toxic materials.

(Source: Therivel, R., & Wood, G.; 2018;)





Now, we can see the indirect source of impact on water. So, we see that roads can also bring changes likewise we see urban and commercial development can bring changes in industrial development as well as we see mineral extraction landfill forestry deforestation, and intensive agriculture.

We see that impact prediction can be qualitative. So, typically informed through professional judgment, it can be assessed by users of checklists, metrics flowcharts, and network analysis. But these tools do not assess the nature magnitude or significance of the impact. Some more complex mathematical models can be used however, they require professional input, and also the data which is invested is of key importance.

Numerous models have been developed for simulating and predicting changes in hydrological system reviews are provided in many hydrological texts. Physical models are also sometimes used, but most modeling involves mathematical and statistical analysis of input data. We will run through the list of software available in the public domain. The use of the model has limitations, especially regarding the time and resource restrictions common in environmental impact assessment, some software is expensive, and most model needs expert input.

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Type of software	Description	Web address
Geomorphology - USA/UK	STREAM POWER SCREENING TOOL Flood Risk Management Research consortium. Simple tool for calculating stream power in any river and related potential for change (e.g. of sediment movement).	https://www.web.sbe.hw.ac.uk/frmrc/downloads/UR9%20signed%20off.pdf
Water quality — USA	BASINS – GIS/model for pollutants from point and nonpoint rural and urban sources. QUAL2E – max. daily chemical streamloads in relation to dissolved oxygen	www.epa.gov

(Source: Therivel, R., & Wood, G.; 2018;)

Type of software	Description	Web address
Water quality USA	WATERSHEDSS – online package to assist in formulating mitigation/management for non-point source pollution. Includes information on pollutants and sources, and a linked GIS/water quality model.	http://www.epa.g-ov/exposure--assessment-models/wat-ershedss
Water quality UK	HAWRAT (Highways Agency Water Regulation Assessment Tool) – assesses the risk of pollution to surface waters from highway runoff. Looks at soluble pollutants (e.g. zinc, copper) and sediment-bound pollutants.	http://infrastr-ucture.plann-ingportal.go-v.uk/

(Source: Therivel, R., & Wood, G.; 2018;)

Type of software	Description	Web address
Water quality — Australia	AusRivAS (Australian River Assessment System) – an adaptation of the River Invertebrate Prediction and Classification Scheme allows rapid sampling to be used for predictive models of macroinvertebrate communities using a reference site database. Comparisons are made between 'predicted' and 'actual' taxonomic compositions to indicate a site's ecological health. Can assess the biological responses to changes in water quality and/or habitat condition in rivers and be integrated with the existing network of physico-chemical water quality monitoring sites.	http://ausri-vas.ewater.o-rg.au/
Water quality — USA	NAWQA (National Water Quality Assessment) – determines status and trends in contaminant, nutrient and sediment loads and concentrations and related trends in ecological conditions. Uses ground monitoring (including water quality monitoring sites and aquatic ecological conditions) and integrates this with modelling and other scientific tools to extend the water quality knowledge to unmonitored sites.	http://wa-ter.usgs.-gov/nawqa/
Water quality – worldwide	World Water Quality Assessment – UNEP assessment that aims to identify current and future problem areas of freshwater quality in surface waters, and to propose and evaluate policy options to address problems. Involves 1. A bottom-up analysis of data sources, and 2. Top-down modelling of water quality on the continental scale	www.unep.org/dewa/

(Source: Therivel, R., & Wood, G.; 2018;)

Examples of hydrological, hydraulic modelling and water quality software provided by Government Agencies

Type of software	Description	Web address
Hydrologic (watershed model) – USA	HEC-HMS (Hydrologic Engineering Center Hydrologic modelling system). Simulates the complete hydrologic processes	http://www.hec.u-sace.army.mil/
Hydrologic (flood estimation) — UK	FEH CD-ROM Digital descriptors (e.g. boundaries, drainage paths) for catchments ≥ 0.5 km2 ; rainfall depth-duration-frequency (DDF) data for catchments and 1 km grid points; a user-interface for selection of catchments/points; facility to compute design rainfalls, or estimate rainfall event rarity, from DDF data.	www.ceh.ac.uk

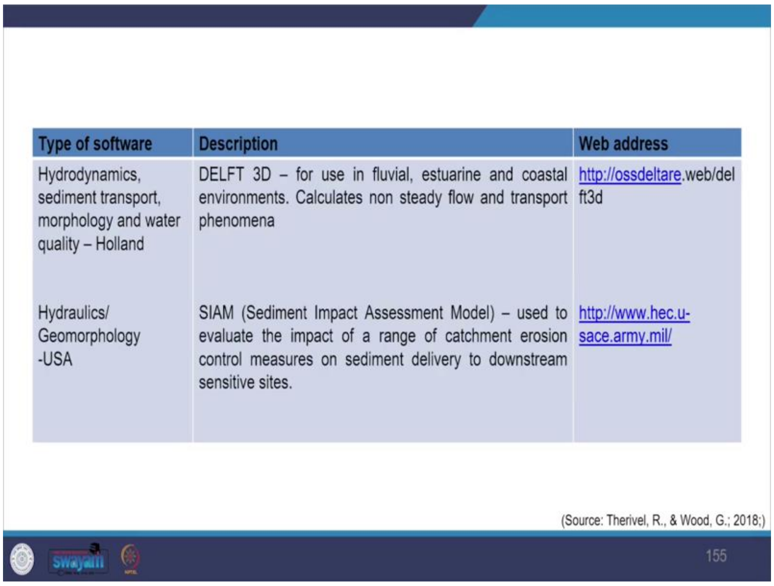
(Source: Therivel, R., & Wood, G.; 2018;)

Type of software	Description	Web address
Hydrologic (flood estimation) — UK	WINFAP – given annual maximum flood data for a site, can estimate probable events, e.g. the magnitude of an event in a given return period, or the return period of a flood of given magnitude. WINFAP-FEH – Flood frequency analysis methods using FEH CDROM.	www.ceh.ac.uk
Hydrology — USA	WinTR-55 – US Department of Agriculture. Urban hydrology for small watersheds.	http://www.nrcs.-usda.gov/-wps/portal/n-rcs/detailfull/-national/wat-er/?cid=ste-lprdb1042-901
Hydrology — Canada	WATFLOOD — used to forecast flood	www.watflood.ca
Hydrology-hydraulic water quality — Canada	A SWMM – a dynamic hydrologyhydraulic water quality simulation model used for analysis and design of stormwater infrastructure	www.epa.gov/water-research/storm-water-management-model-swmm

(Source: Therivel, R., & Wood, G.; 2018;)

Type of software	Description	Web address
Hydraulic (flood Analysis) —USA	HEC-RAS (Hydrologic Engineering Center River Analysis System). Computer model of the hydraulics of water flow through natural rivers and other channels.	www.hec.usace.army.mil
Hydraulic France	TELEMAC-2D – used to simulate free surface flows in two dimensions of horizontal space	www.opentelemac.org/

(Source: Therivel, R., & Wood, G.; 2018;)



Type of software	Description	Web address
Hydrodynamics, sediment transport, morphology and water quality – Holland	DELFT 3D – for use in fluvial, estuarine and coastal environments. Calculates non steady flow and transport phenomena	http://ossdeltare.web/delft3d
Hydraulics/ Geomorphology -USA	SIAM (Sediment Impact Assessment Model) – used to evaluate the impact of a range of catchment erosion control measures on sediment delivery to downstream sensitive sites.	http://www.hec.u-sace.army.mil/

(Source: Therivel, R., & Wood, G.; 2018;)

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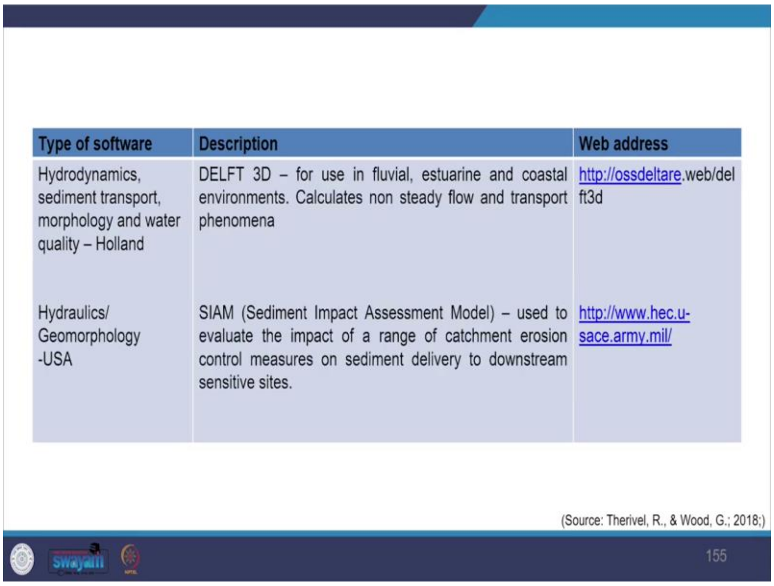

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(Source: Therivel, R., & Wood, G.; 2018;)

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So, we see the Hydrological Engineering Centre hydraulic modeling system, which is available for hydrologic watershed models, and so on, we see the entire list here. We can also see when (())(38:06) and all these software's which are provided for all the purpose from different countries and most of them are available in the public domain. So, we see the evaluation of impact significance.

So, EIA practitioners are familiar with combining the magnitude of impact with the value of an individual receptor to derive levels of significance. So, depending on the receptor, how significant is the impact, so that is evaluated here. The metrics will need to be used, and they provide the overall assessment in line with the local circumstances. We will see the examples of criteria for assessing the magnitude of impact on the water environment, no doubt, different criteria will be relevant for different projects, but we are looking at the broad approach.

So, we look at how the project activity would have a major impact adverse or beneficial moderate adverse or beneficial impact, and then minor adverse or beneficial impact, or will have a negligible impact depending on the kind of results we get in the domain, the list is provided to you. Likewise, we also look at the sensitivity of the receptor. So, how sensitive is the receptor? Very high, the sensitivity is very high or the sensitivity is just high. So, according to that, we decide what kind of actions have to be taken here. So, we see the parameters used for evaluating the sensitivity, sensitivity of the receiving environment.

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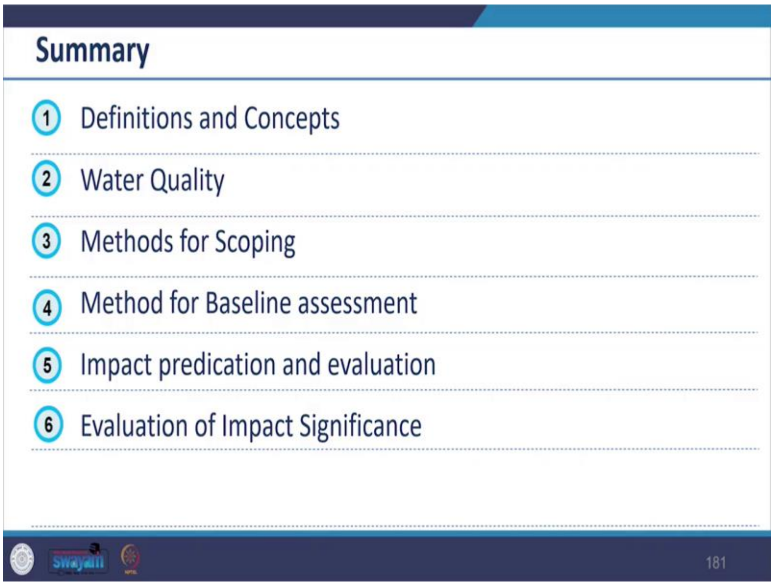

Summarizing, today we saw the definitions and concepts, we also looked at the water quantity, we looked at the concept of water quality, and also looked at the fluvial geomorphology. So, we also looked at the methods for scoping like the checklist source pathway receptor model, we looked at the baseline assessments impact prediction and evaluation, and we looked at the list of software which are available. And then we looked at the evaluation of impact significance.

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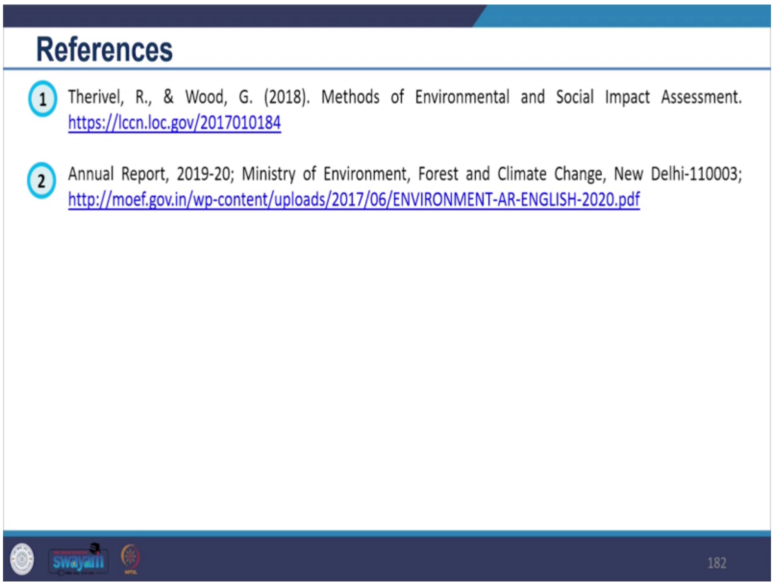

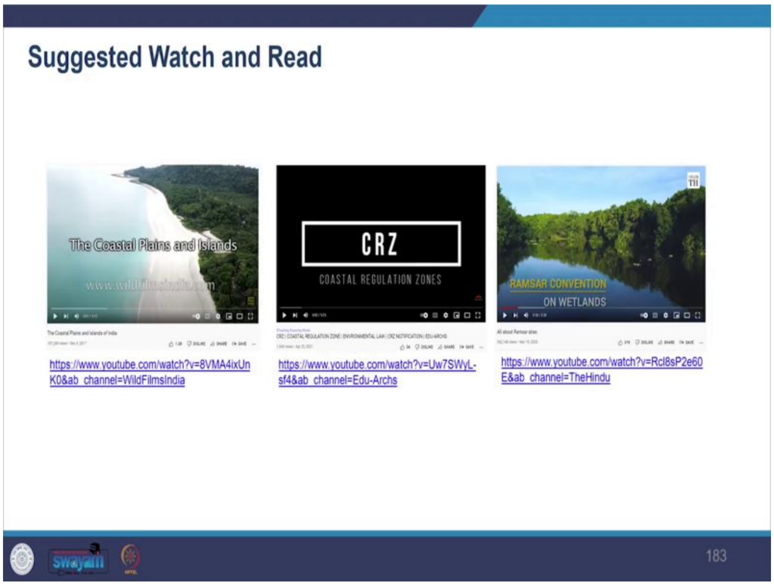

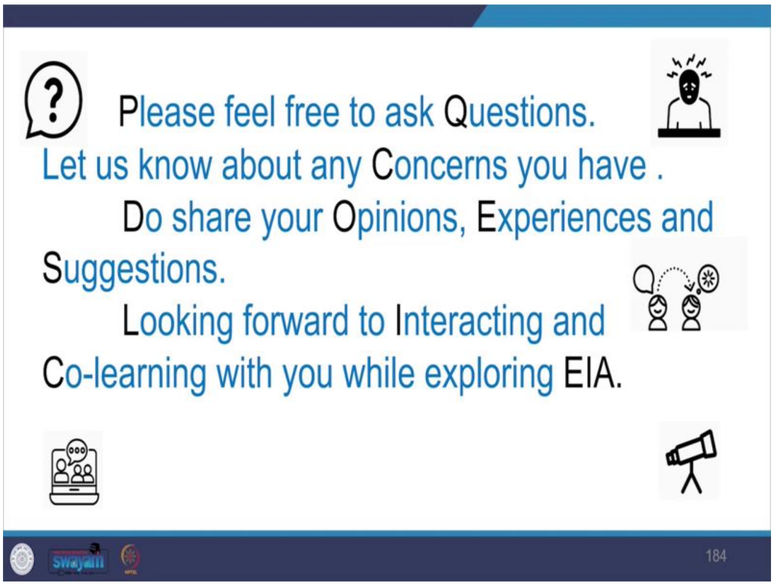

So that is all for today, these were the references used, and these are the suggested watch and read because our coverage is very limited. So, you can read more if you are interested in exploring further. Please feel free to ask questions. Let us know about any concerns you have to share your opinions, experiences, and suggestions looking forward to interacting and co-learning with you while exploring EIA. So, that is all for today. Thank you.