Environmental Impact Assessment
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Lecture 52
EIA Methods – Resource Efficiency

Welcome to the course Environmental Impact Assessments. And in today's session, we are going to cover Resource Efficiency. We are going to look at what methods we adopt within the umbrella of EIA. So, the key reference for us for this is like from our text course book, which we are following in chapter 17, which deals with resource efficiency.

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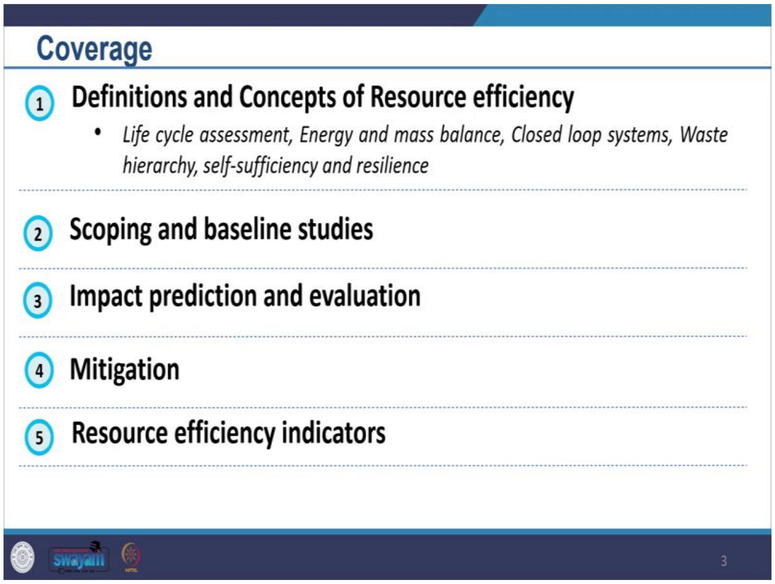

So, our coverage for today would include that we are going to looking at the definitions and concepts of resource efficiencies where we will look at some of the models, which are their, lifecycle assessment, then the energy and mass balance concept we will try to understand and then we will also try to understand what are closed-loop systems and then what is a waste hierarchy, self-sufficiency, and resilience concept.

Further, we will look into what we look into. While we undertake scoping and baseline studies about resource efficiency. Further, we will look into how we undertake impact prediction and evaluation while dealing with this domain. Further, we will look into the mitigation measures that are available in this domain in a very brief manner, and then we will look at some of the resource efficiency indicators.

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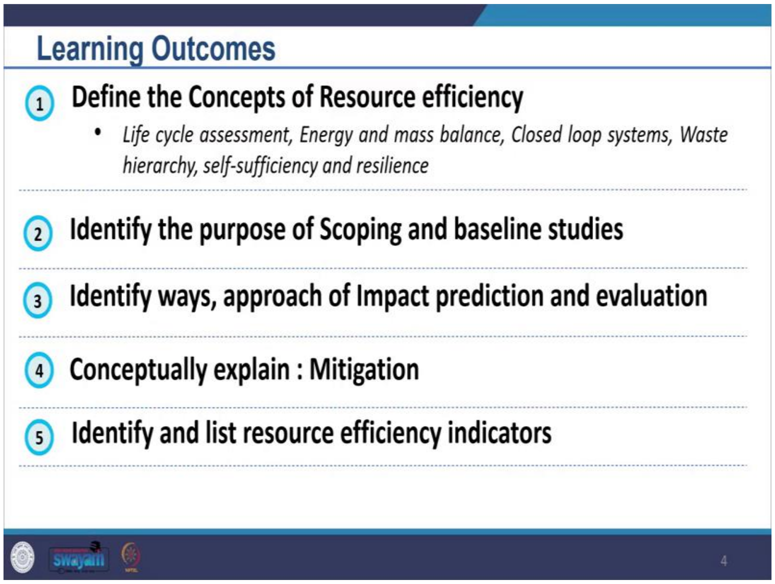

So, accordingly, the learning outcomes expected learning outcomes are that after completion of this particular session, you should be able to define all the concepts related to resource efficiency, further, you should be able to identify various purposes and steps involved in scoping and baseline studies. And you should be able to identify ways approach to deal with impact prediction and evaluation. And then, how you would deal with mitigation you would conceptually explain that and then also tell the steps and roles in that or certain methods involved in that. Further, you should be able to identify and list some of the resource efficiency indicators.

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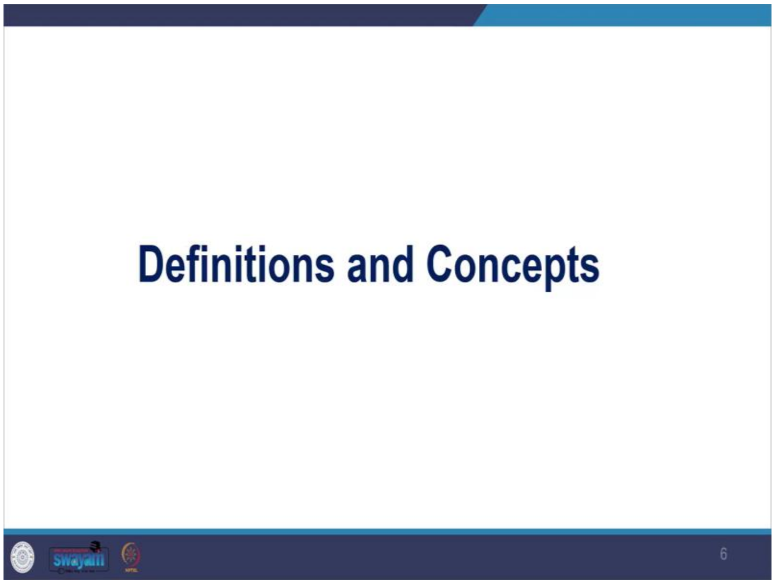

So, understanding resource efficiency, deals with how carefully resources are used, what kind of waste is generated in the process, and how you manage that. And you look at it at all the stages of the project from project construction to operation till the project is decommissioned, or pulled down. So, usually, if you will see this resource efficiency, it is not taken separately, a separate section in EIA, but it is very well integrated into the EIA process. But at the international level, this practice is now changing with IFC performance standard 3, suggesting resource efficiency and pollution prevention and its standards guidelines.

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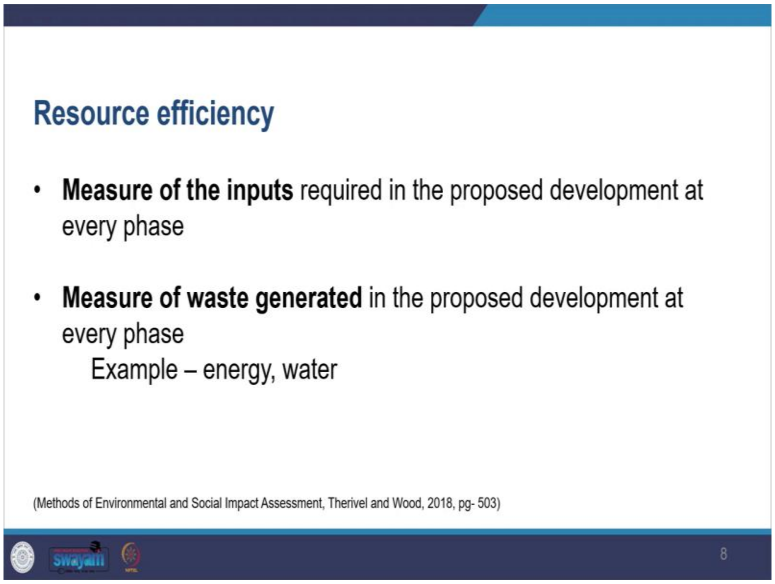

So, looking into the definitions and concepts involved, or we see resource efficiency, what does that mean? So it looks into the measures of input and measures of output and measures of waste. So, measures of input, like what resources, it is consuming for various stages and the stages of construction in the stages of operation and decommissioning. So, how much resource it is consuming?

Then you also look into you measure what how much waste is generated in the proposed development. And this again, you look at every stage, how much waste you are generating at the time of construction, what waste you are generating at the time of operation, and when the project is pulled down.

So, you look into resources if we talk about, you look into how much energy it is consuming, how much water it is consuming, and any raw material, what it is using, how much consumption is there. So, you measure that input and you also measure the waste which is generated out of your project. So, another concept and key way of looking into it is lifecycle assessment. What is lifecycle assessment means that you look into how is the life of the product in terms of how it is consuming energy and how it is releasing, what kind of waste are releasing.

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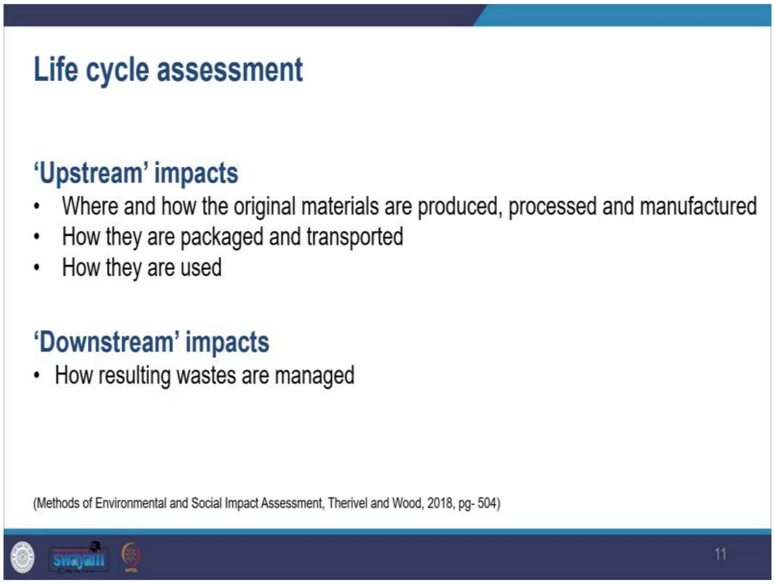

And then within this, you also see the concept of upstream impact and downstream impact. So, the upstream impact would mean where and how the material is produced, how it is processed and manufactured, how it is processed and how it is manufactured, how it is packaged and how it is transported, and how it is used, so, that is the upstream impact of the project what we say.

Then there is the downstream impact which deals with mostly the residual waste that is generated and how the resulting waste is managed, how do you recycle it, reuse it ultimately take it to the landfill site, or generate energy with that? So, how the waste out of your project is dealt with that deals with the downstream impact? So, we have seen upstream impact and downstream impact related to the lifecycle assessment.

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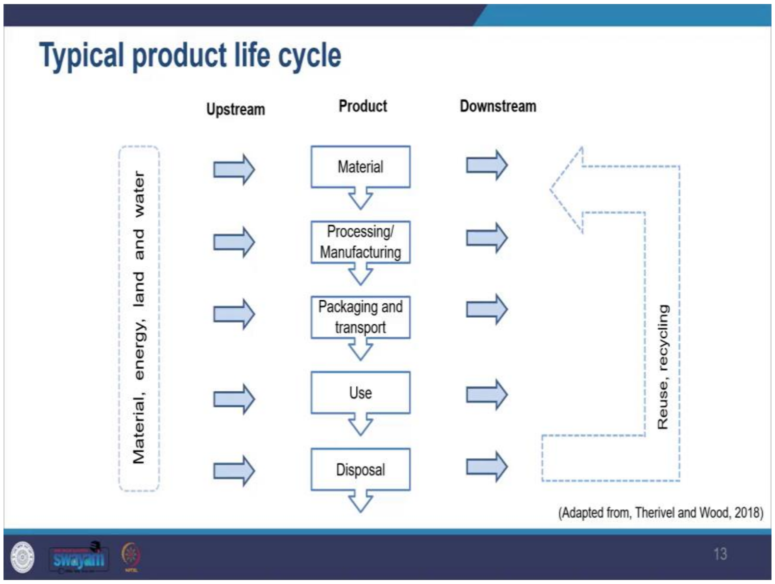

So, here in the diagram, you can see the upstream and downstream and you can look at the product life cycle here looking at the product life cycle, you see the material which is which comes and then how it is processed, manufactured and it is packaged, transport and then it is put to use and then eventually it is disposed and then all the process till it is dispose, it is said to be upstream if you want to see diagrammatically and then after it is disposed of, how do we reuse recycle and make it as a material again is seen as a downstream.

So, the purpose here when we deal with resource efficiency is to minimize the use of input and also minimize how much waste is generated. So, when we look at life cycle assessments, we measure the environmental impact of the product or the services. So, that is what we do. Lifecycle assessment particularly in the context of EIA considers the amount of resources that are used at the different stages of a product or a project.

So, for example, what do you choose to use the typology itself, and to what quantity do you want to use? So, if you use steel compared to alternative building materials, such as bricks or concrete, you will see that steel has larger and voided energy than the alternative material. So, that waste is less resource-efficient compared to the alternative materials here. So, that is what the assessment has done when we look at the lifecycle assessment.

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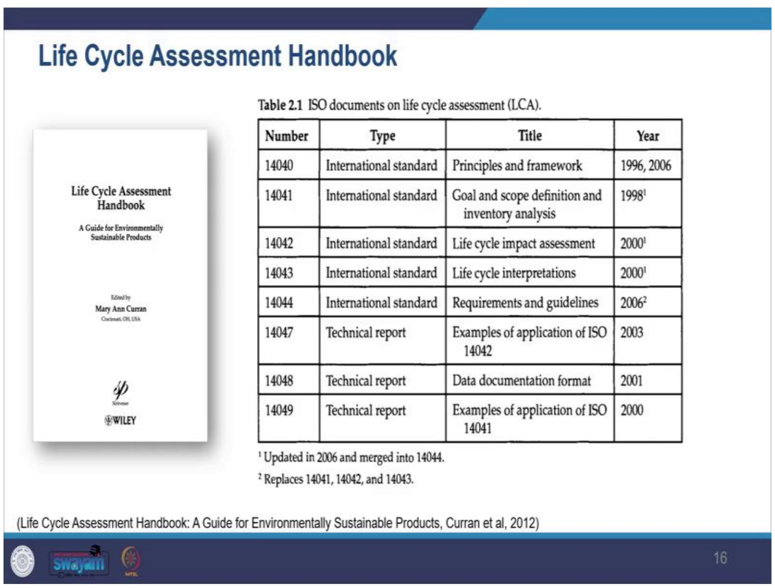

Table 2.1 ISO documents on life cycle assessment (LCA).

Number	Type	Title	Year
14040	International standard	Principles and framework	1996, 2006
14041	International standard	Goal and scope definition and inventory analysis	1998[1]
14042	International standard	Life cycle impact assessment	2000[1]
14043	International standard	Life cycle interpretations	2000[1]
14044	International standard	Requirements and guidelines	2006[2]
14047	Technical report	Examples of application of ISO 14042	2003
14048	Technical report	Data documentation format	2001
14049	Technical report	Examples of application of ISO 14041	2000

[1] Updated in 2006 and merged into 14044.
[2] Replaces 14041, 14042, and 14043.

So, you are again, there is a handbook which you can see lifecycle assessment handbook, by Curran. You can see here, so, I have, you can look at this particular handbook, it sure should be available. And there are a lot of standards and guidelines which are available to undertake the lifecycle assessments. So, international standards are available technical reports are available, I have just left the list for you. It is said that lifecycle assessment is technically a very complex subject and like, you can see this handbook available for further guidance on that.

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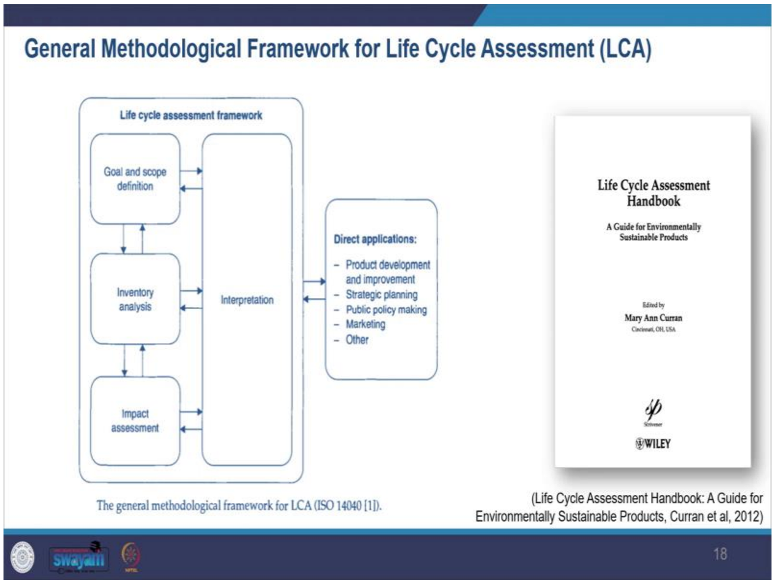

Looking at the general methodology, which is adopted for this purpose, the kind of framework which is adopted for this, you can look at this diagram, you can see a taken from Curran's book or you can see the lifecycle assessment framework. So, you first look at the goal and scope and the definition of it. And then you have intensive inventory analysis and then you assess the impact and then inventory analysis at all these stages there will be interpretation.

And then you will be looking at the direct applications like product, development, improvement, and how you improve the product. How do you strategically undertake planning and then how do you connect with public policy? How do you the marketing and then the other aspects, of all the policy aspects if you remember all the tools we had talked about? So, that is how the lifecycle assessment framework is taken care of in a very broad manner.

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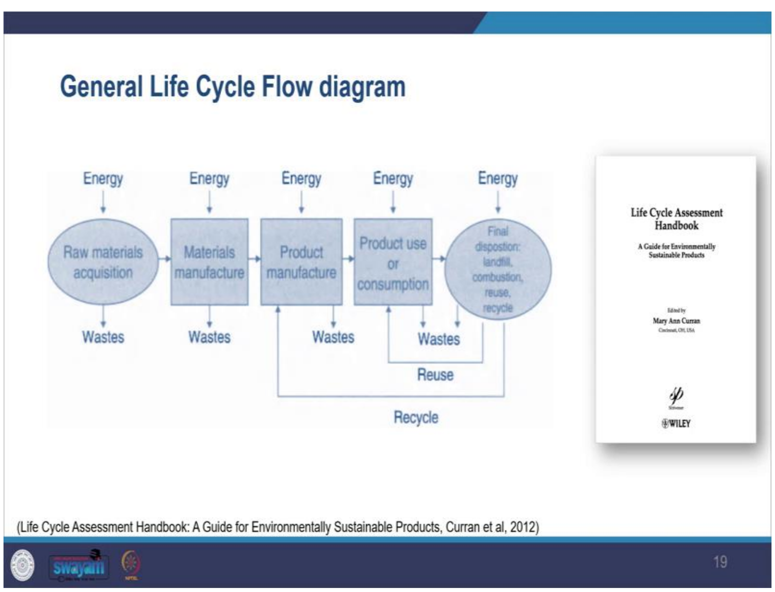

Here in this example, you can see the general lifecycle flow diagram. Here you can see, how the raw material is acquired, and even when the raw material is acquired, there is a certain consumption of energy and then at that stage itself, the waste is produced. Then, the material when is manufactured after acquiring the raw material, again the energy is consumed in the manufacturing process and then the waste is generated.

Likewise, you see the product manufacture when all the raw materials come together and the product is manufactured, you have energy consumption and the waste is there, and then when the product is used or consumed like energy is again consumed at that stage, and then you might also find waste and then when the material is no more usable, then you finally dispose that, and that at that disposition also you can you consume energy and then even that produces waste and that waste can be reused or recycled.

So, that is how you see the general lifecycle flow diagram. So, think of it in a very simplistic manner, you can think of the television, television manufacturing, how the raw materials come for that, what basic raw materials are there, how the final television is prepared, and then how it goes for the consumption purpose and when you dispose of your television how that how do you dispose it and how it is recycled or so on. So, you can think of a computer as well, or any material with which you deal. So, that would allow you to think of the general life cycles, of the product.

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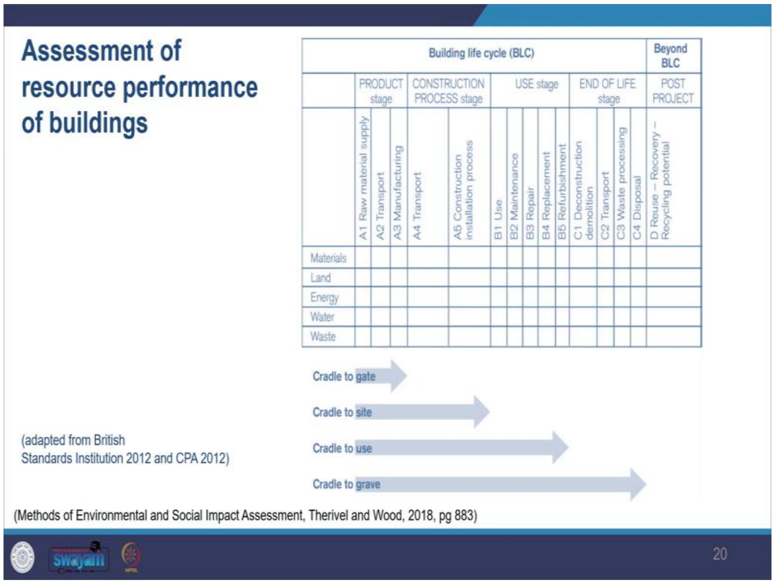

Again, here in the diagram, you can see the assessment of the resource performance of buildings. This is again adopted from the it is British standard. And here you can see how they are looking at the building lifecycle, and looking at the resources, how the resource is being consumed at all the stages. So, you can see the product stage, raw material supply, transport, manufacturing, and then the construction stage, transport construction, and installation process.

Also, it is the use stage, how you are using, use, maintenance, repair, replacement, and end of the life stage where you have deconstruction, demolish, and transport, waste processing, and then post-project where you are recycling, recovering, or reusing all the materials. So, that is what you can see here, so, that was about the lifecycle assessment. Now come familiarizing ourselves with the other concepts, that is energy and mass balance. So, this is an important component, when we deal with resource efficiency.

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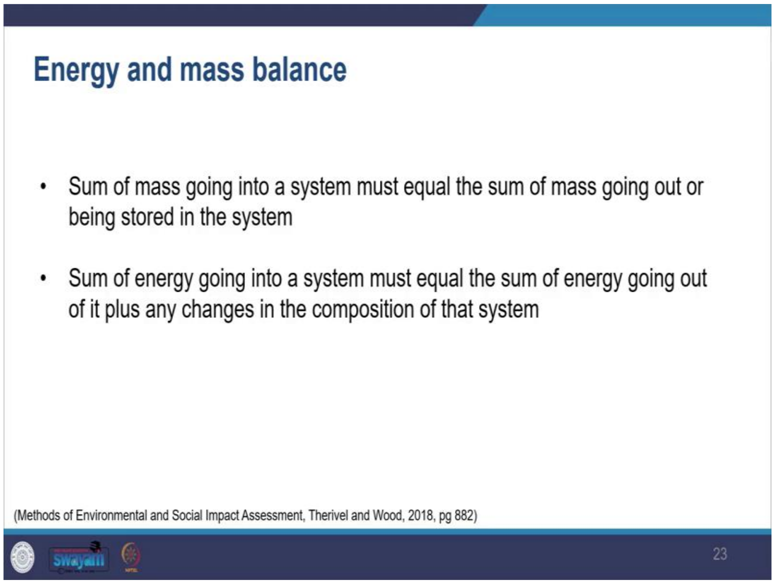

And when we talk about energy and mass balance, it means the sum of mass going into a system like the total energy getting into the system must be equal to what is coming out of the system. So, there should be a mass balance. And that sum of energy that goes into the system must equal the energy that is going out, plus the changes in the composition of that system.

So, it might be either input and output are equal or there might be input and some changes in the system and the output. So, that equates to energy balance. And, in the process of assessment, we ensure that all these inputs and outputs are accounted for. So, you take care of all these aspects when you deal with it.

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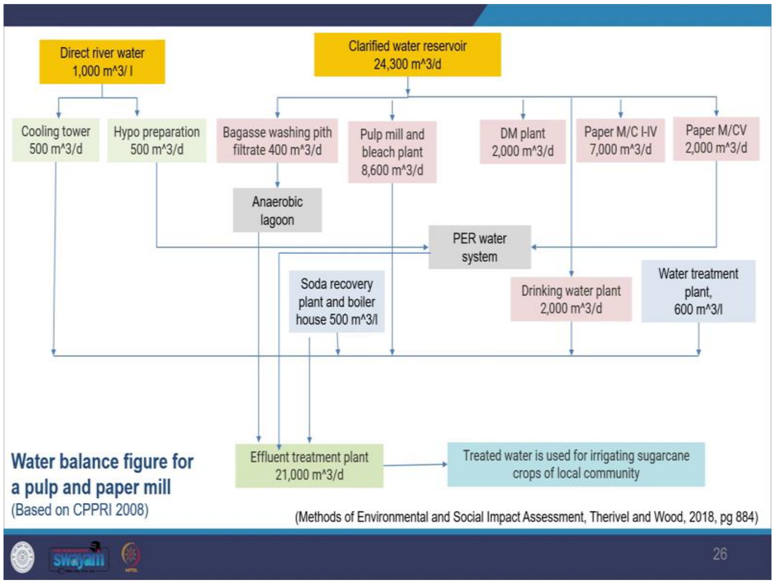

So, here in the image, you can see from the example how all the resources have been taken care of at various stages how the input-output has been accounted for, and what kind of input is going how, and none of the arrows are left hanging in the system.

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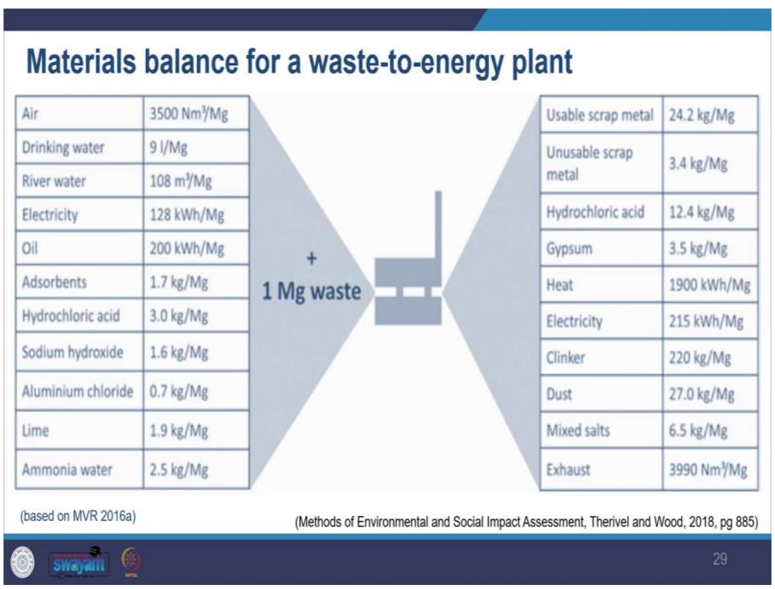

So, another example you can see here, is how the balance is checked, how the what kind of resources have been put into the system, and what kind of outputs they are getting from the system. So, you can see these examples.

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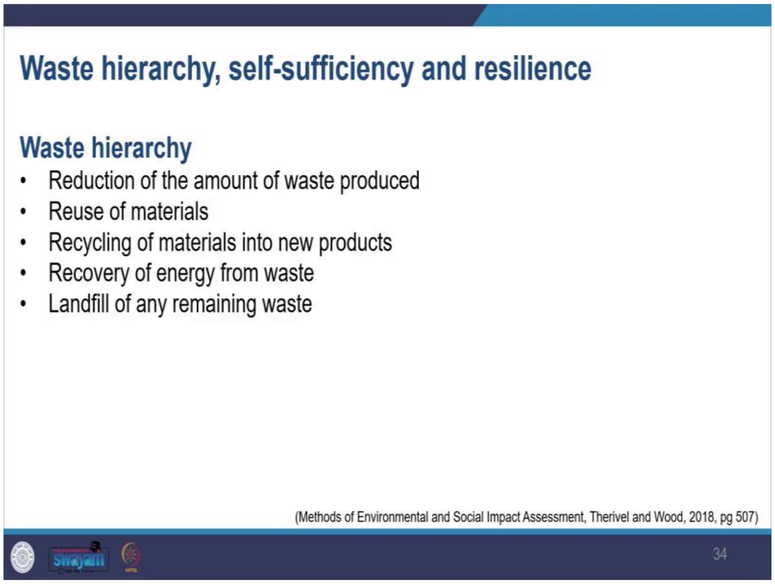

So, looking at another concept, you see a waste hierarchy, which looks into self-sufficiency and resilience. So, looking at waste hierarchy, so, waste hierarchy the concept is like how do you handle waste? So, the first idea of handling waste is to reduce the amount of waste that is produced. So, you try to reduce, reduce, R for reduction, and then you see how you can reuse the material that whatever waste has been produced, how do you reuse those materials, and then, you further look into how you can recycle them into a new product.

So, how out of all the waste new products can be created? And then if not, if all of these cannot be done after that also one can recover the energy from the waste. So, whatever is the waste, finally, you can convert it into energy. And then after all these things reduce, reuse, recycle, and recover energy once you have done that, the waste can be sent to the landfill site, as the residual remaining waste. So, that is about the waste hierarchy.

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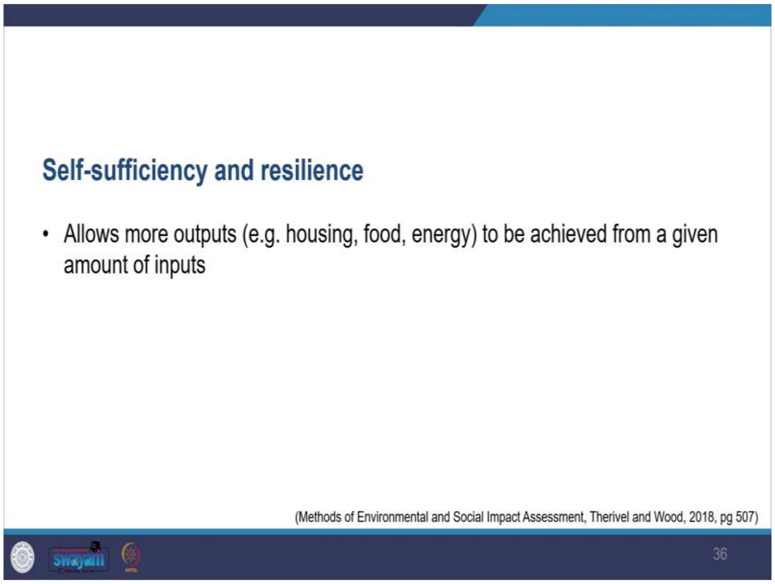

Now, looking at self-sufficiency and resilience, so, what is that? So, when we look at self-sufficiency and resilience, the system allows more output to be achieved in the given amount of input. So, how you can have systems efficiency? So, how you can, by whatever input is been getting is been given you are trying to maximize the output from that particular input. So, you see examples include LED light bulbs, which allow many more lumens per watt than the traditional incandescent bulb.

So, how efficiently you can use it? So, process improvement. So, all those deal with self-sufficiency and resilience as well as in the case of settlement also you are seeing that these days high density is being much more promoted given the understanding that it allows resource efficiency in terms of how much energy is consumed, how much energy is shared, so, which leads to economical use of those resources. So, that was about the definitions and concepts.

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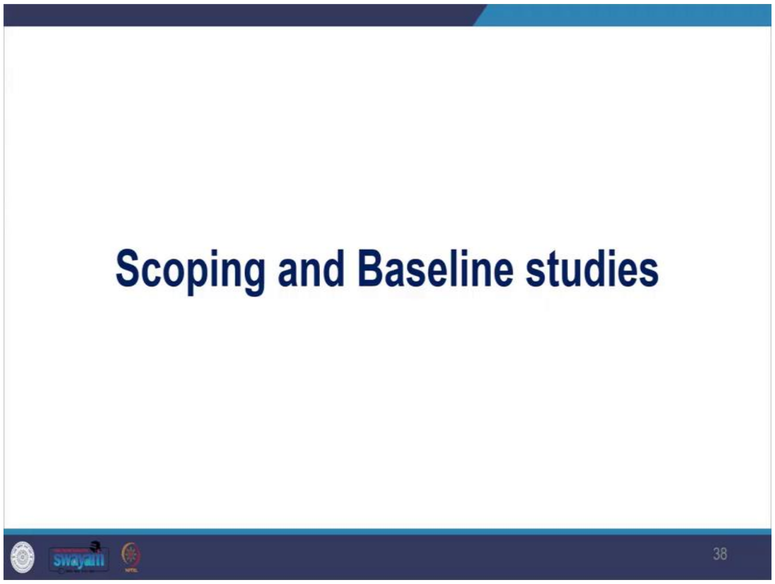

Now, moving on, we will look at the scoping and baseline studies. So, the purpose of scoping and baseline study is you identify which issues relating to resource efficiencies are important for project planning and important for decision-making. So, you identify the important issues here.

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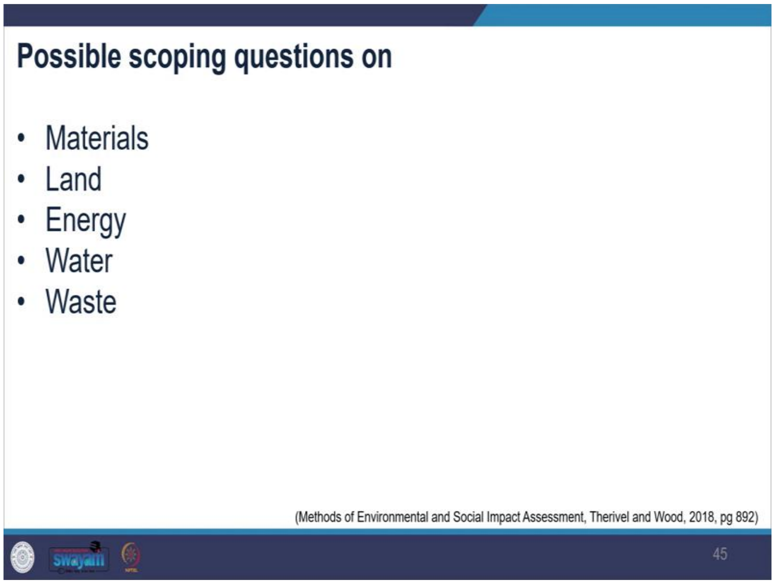

So, in this stage, you have possible questions, which you look into. So, while dealing with material, you will look into whether the project will use, what material the project is going to use, is it very limited. And is it a scarce resource, and at what stage you are going to use it to what quantity you going to use it, and then and whether you going to use any harmful material, and do you need to handle it in a various special way?

So, you need to look at all those aspects here. And, then you will also look at once you understand the resources, you will also look at the impact it might have on the environment. So, will that particular usage of the material would lead to like, how much quantity of material do you need and how it is going to impact the project? So, that is all you need to see here.

And then further similarly, the material and the resources in terms of land. So, how much land you are going to use, is it suitable? The land is suitable for the purpose or not? And how much like when you are looking at the impact, how much footprint you are occupying for the particular project, and what kind of land you have taken for that purpose. So, likewise, you will look into energy, like what kind type of energy you are producing in the given context and how you are using it, whether it is renewable energy or not.

And then, whatever energy you are going to use, whether you will be able to get it from the available infrastructure or you would need additional infrastructure for that. And whatever you consuming is the system, existing system resilience to take care of that requirement of yours can that take it or not. So, all these aspects like you would be looking at, water then raising similar questions, like are you building a project in the water-scarce area or you can take care of that fulfill that requirement and then as the water infrastructure resilience in your context or not. So, likewise, you look for the waste, and likewise, you will look for all the other aspects.

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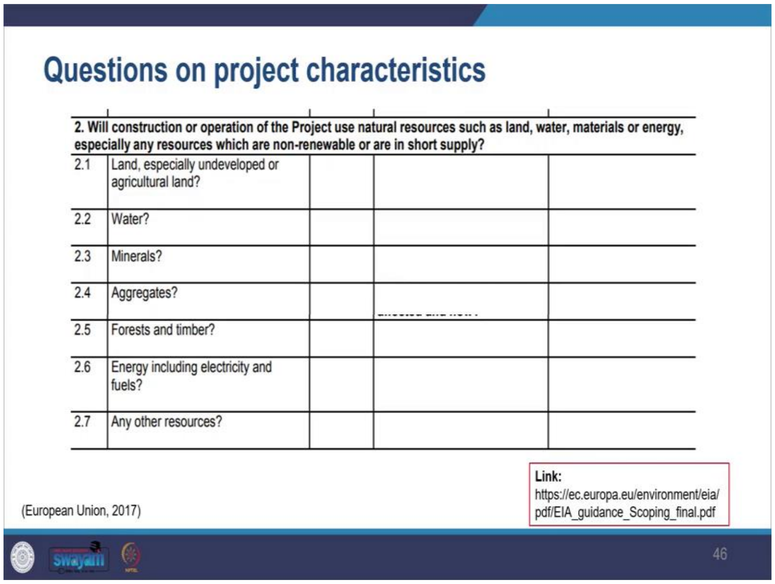

So, there is another example which we see here. I have taken it from EU guidance on environmental impact assessments. So, you can see, like I said, rarely it is segregated as a separate section, it is very much inbuilt. So, I have snipped a checklist from the EU document, which within itself allows you how during the scoping stage, you can undertake the resource assessment. So, you can see point number 2, will construction or operation of the phase use natural resources such as land, water, material, or energy, especially any resource which are non-renewable or in short supply?

So, you see how they are looking at the resource efficiency and also looking at the availability of the resource. So, the checklist questions like land, especially undeveloped or agricultural land, what is the scenario with water? And what is the scenario with mineral, aggregates? Whether it is yes or no? And then giving it in a descriptive format, what is the characteristic of the project environment? Would, could be affected, and how?

And is the effect likely to be significant, why? So, in the checklist method, you are also checking the significance of the particular observations you are making. So, likewise, you will be looking at the forest and timber energy including electricity and fuels and any other resources, which you are using for the purpose.

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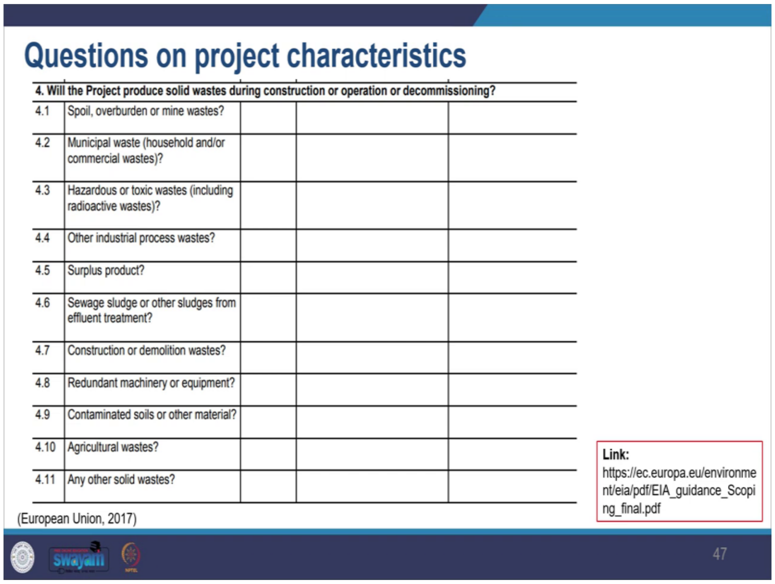

Further from the same checklist have taken, how they are dealing with the solid waste during the construction operation or decommissioning stage. So, you can see the spoil, overburden mines mine waste, and municipal waste. hazardous or toxic waste, other industrial process surplus productive, sewage sludge, construction or demolition waste, redundant machinery or equipment, contaminants, soils or other material, agriculture waste any other solid waste.

So for all these, you look at whether you will be using, yes or no. What will the characteristics of the project environments, will it be affected or not? And then what will be the significance of it? So, this these kind of checklists are used at the scoping stage to look at resource efficiency. This example is the inbuilt checklist, the previous one you saw, was like a specific checklist that can also be integrated with the main EIA report.

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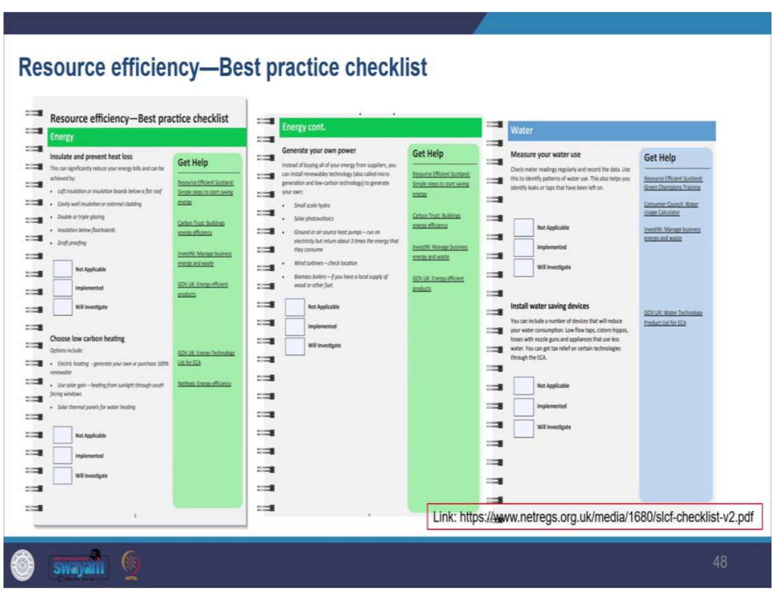

I have taken from resource efficiency best practice checklist, I have also given you the link so that you can download this checklist. So, here again, you can see how they have prepared a checklist where they look at the energy or water. And then whether, it is specific details about that, whether it is going to reduce your energy bills or not, what kind typologies there, and whether you are choosing low carbon heating, and are you going to generate your power, then how you are going to measure your water use, and what are the installations you are doing for saving water.

So, all those kinds of checklists are there. So, that was about the scoping and baseline study. So, those things are available, and I am also giving the link to all those examples there.

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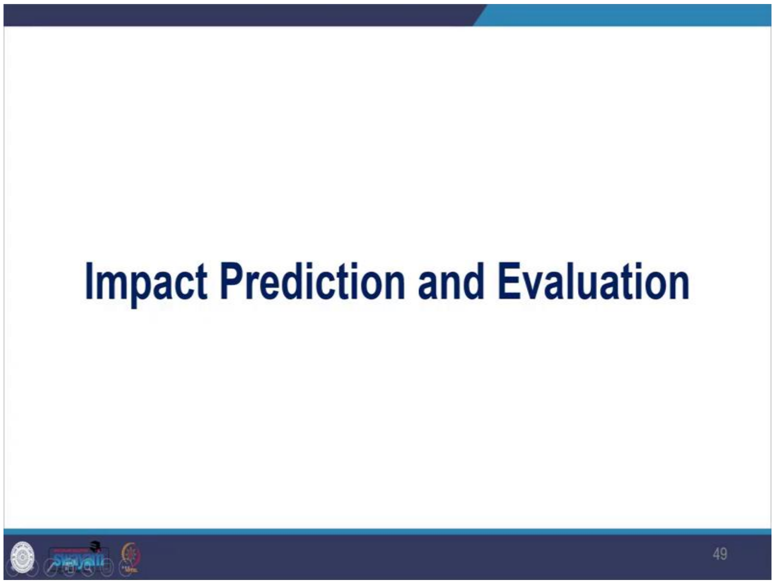

Now moving on, we will look at the impact prediction and evaluation. So, part of it, we also saw in the checklist method, how they were looking at the significance of the impact which might happen. So, now, in this particular stage, you identify issues significant concerning project environmental impact. So, whether whatever impact you have identified in the scoping stage, you will try to look at the significance of that impact.

And in this stage, you will make a detailed prediction of what will happen you further put it into the detailed study and you look at the significance of the kind of change that will happen. And you also look at whether whatever kind of changes are happening will need mitigation measures or not.

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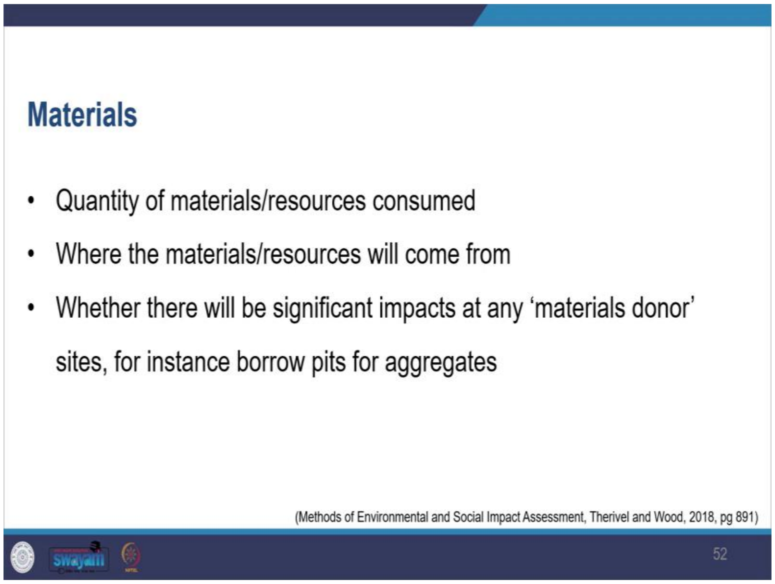

So, examples of how you would look into it include what will be the quantity of material resources consumed and you would be looking at the details of its typology. For every project stage, you would be looking at, and then you would be looking at from where the material is coming from, and whatever resource you are using from where it is coming, and then you will also look at what kind of impact any material would have on your project site or the environment. So, that is all you will be looking at as you also saw in the checklist, so that would help you in the assessment of the significance here.

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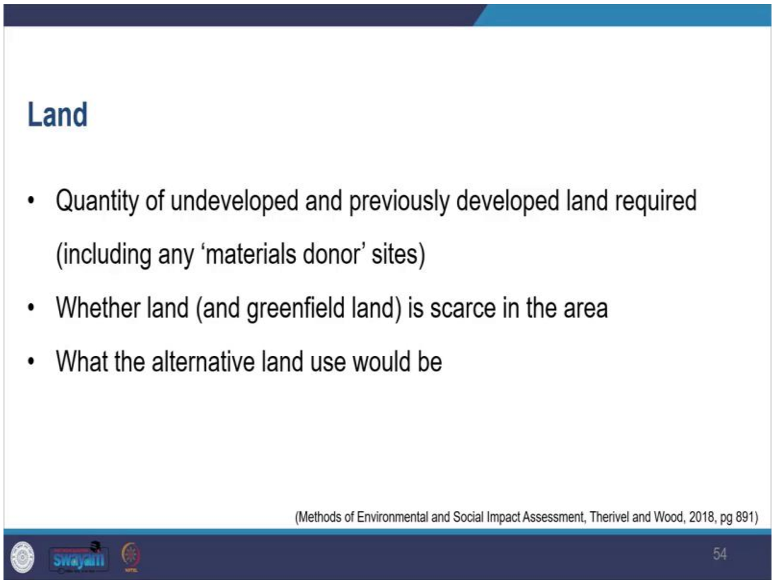

So, likewise, for a detailed understanding, of the material, you might be looking into various resources, like you might be looking at the land resources, and you have already studied how to evaluate land resources, but here, what you are also doing is quantifying and also looking at from the resource efficiency point of view. So, the detailed pattern you know, a here about, but the how you would use it in this context, that is what you want to learn here. And then, you have to be careful whether these resources are scarce in that particular area, wherever your project is coming up.

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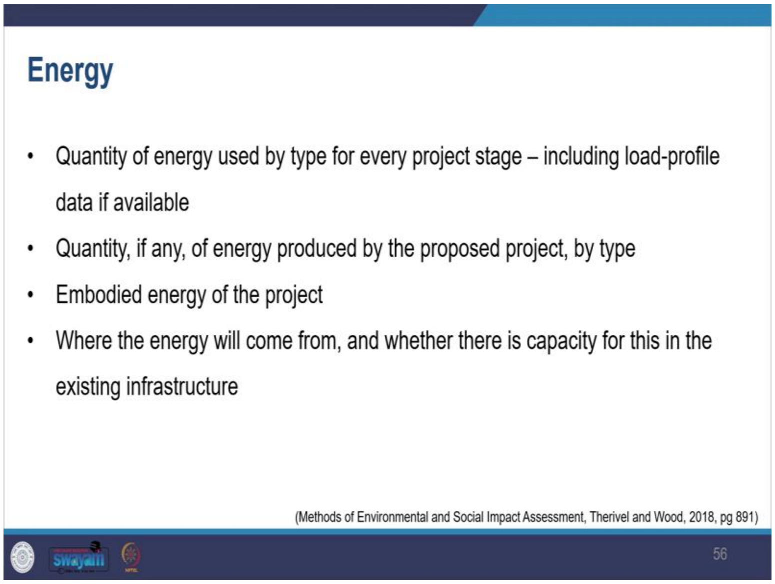

And then similarly, you will look at the energy, the quantity of energy used for the proposed project. You have to also look at not just the quantity but the type of energy, what type of energy you are using? Whether it is renewable energy format, form or not, and at what stages you are using, you are careful that if it is only for a shorter duration, it might be acceptable, but if it is in the operational stage, and it is continuous demand, you might have to look for that.

And there is another term when you deal with all the resources is the load profile. So, looking at what this load profile means, as the energy needed over time, like how much energy you will need in days, weeks, and years. So, you also need to identify the load profile. So, what is the load profile of your project at every stage, at the construction stage, at the operational stage, and the decommissioning stage?

So, you need to quantify and look at it and you may also familiarize yourself with the embodied energy term. So, here, how much energy is being consumed by that particular product would be embodied energy, and then for the project, any every stage you have to look at how much embodied energy is coming up for that particular stage in your project.

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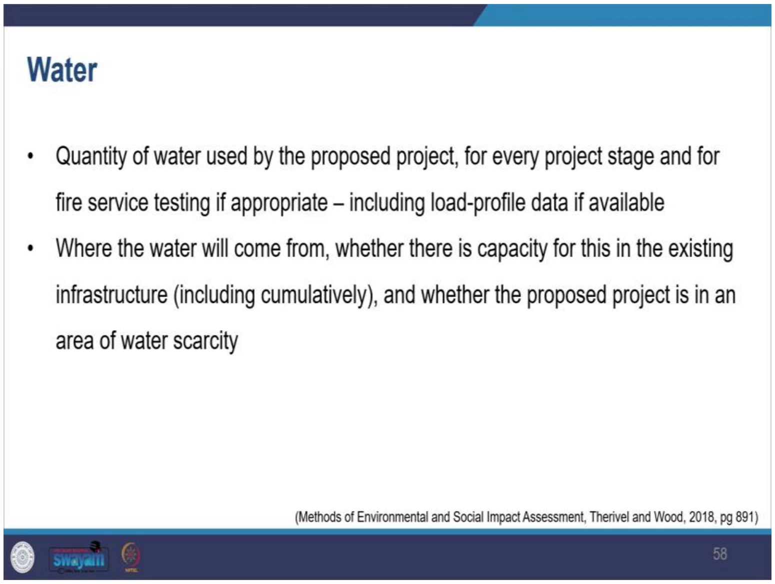

So, likewise, you will be looking at water. The quantity of water used by the form used by your project what kind of emergency services how the water will be used, and how it will be used in the wastage also, and then you here again, you will look at the load profile, and you will calculate this as per the data which is available to you. You will also look at various sources of water from where you are using it and look at what is the capacity of the existing infrastructure to give you water resources for your particular purpose. And you need to check whether it is in the resource care area.

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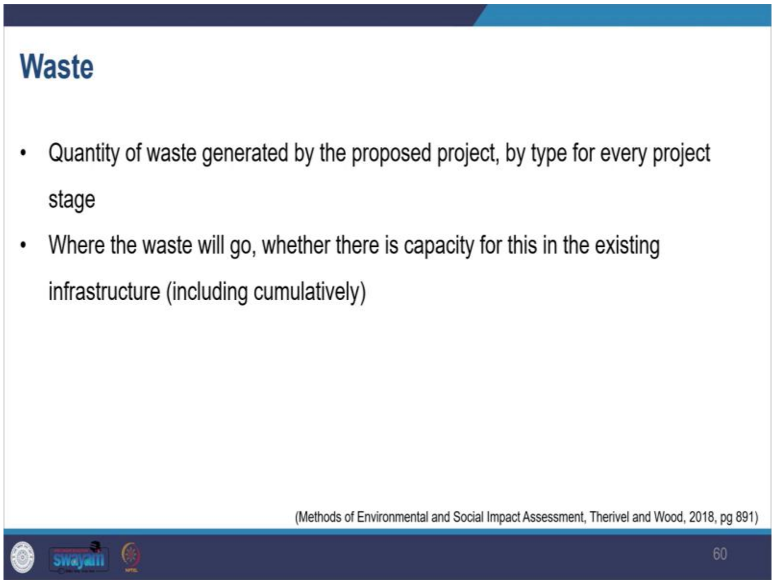

Similarly, you look at the waste, the quantity of waste that will be generated by your project and at what stage it will be produced, and then where the waste will go whether you have the capacity of the area to absorb those wastes or in do have the infrastructure to take care of those waste. So, those things have to be seen here. And you might be, also you might reflect that all the stages might have different levels of impact on the environment.

So, usually, the construction stage might have an extensive impact and negative impact, and even the demolition stage might also have a major impact on the way it generates waste. So, you can also look at varying degrees of impact at various stages.

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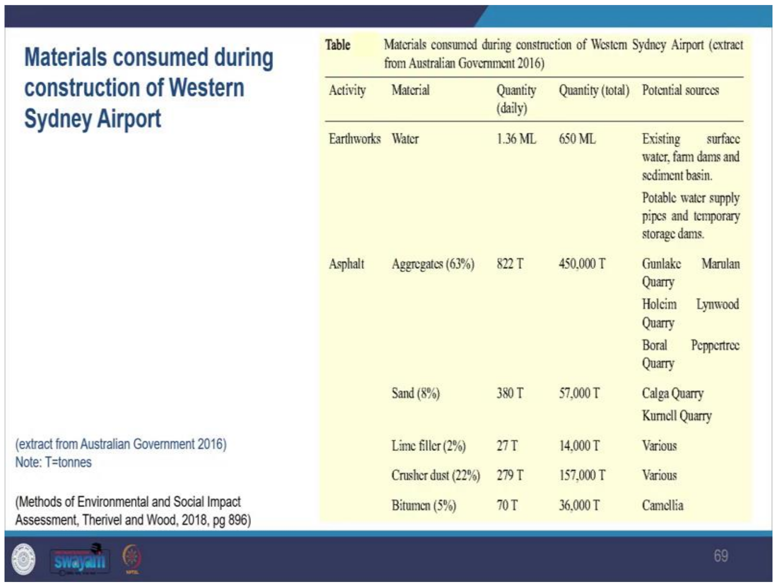

Table Materials consumed during construction of Western Sydney Airport (extract from Australian Government 2016)

Activity	Material	Quantity (daily)	Quantity (total)	Potential sources
Earthworks	Water	1.36 ML	650 ML	Existing surface water, farm dams and sediment basin. Potable water supply pipes and temporary storage dams.
Asphalt	Aggregates (63%)	822 T	450,000 T	Gunlake Marulan Quarry Holcim Lynwood Quarry Boral Peppertree Quarry
	Sand (8%)	380 T	57,000 T	Calga Quarry Kurnell Quarry
	Lime filler (2%)	27 T	14,000 T	Various
	Crusher dust (22%)	279 T	157,000 T	Various
	Bitumen (5%)	70 T	36,000 T	Camellia

So, here in this example, we look at the example of an airport as given in the book, we look at the example of airports from Australia, Western Sydney, and how they are documenting the material. So, material consumed during the construction of the Sydney Airport in terms of tonnes they have recorded so you look at during the earthwork how much water they are consuming. And then what is the potential source and then they have also quantified it.

Likewise, you will see how much asphalt they have used and then in terms of tons and then you also see the potential resources from where they are getting it. So, even a local resource would also save a lot of energy. And then, likewise, you see how they are using concrete, how they are using machinery for operation. So, you can look at this example of how that documentation goes on.

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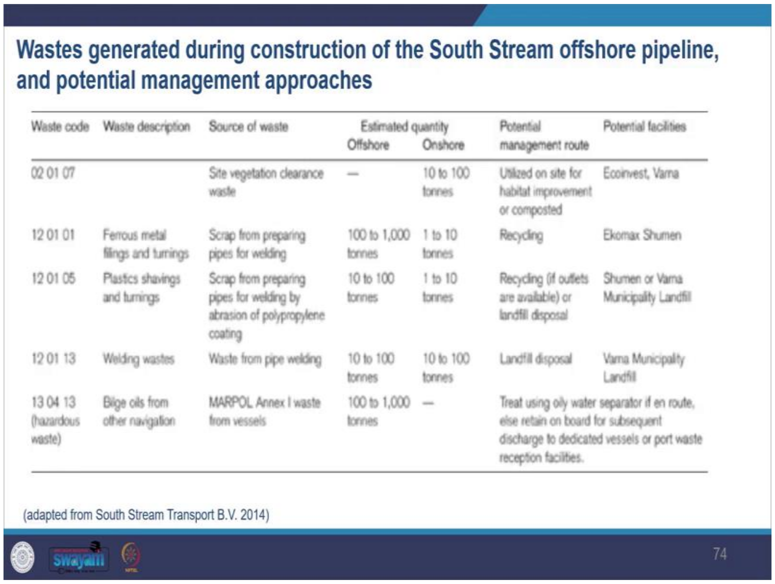

Wastes generated during construction of the South Stream offshore pipeline, and potential management approaches

Waste code	Waste description	Source of waste	Estimated quantity Offshore	Estimated quantity Onshore	Potential management route	Potential facilities
02 01 07		Site vegetation clearance waste	—	10 to 100 tonnes	Utilized on site for habitat improvement or composted	Ecoinvest, Varna
12 01 01	Ferrous metal filings and turnings	Scrap from preparing pipes for welding	100 to 1,000 tonnes	1 to 10 tonnes	Recycling	Ekomax Shumen
12 01 05	Plastics shavings and turnings	Scrap from preparing pipes for welding by abrasion of polypropylene coating	10 to 100 tonnes	1 to 10 tonnes	Recycling (if outlets are available) or landfill disposal	Shumen or Varna Municipality Landfill
12 01 13	Welding wastes	Waste from pipe welding	10 to 100 tonnes	10 to 100 tonnes	Landfill disposal	Varna Municipality Landfill
13 04 13 (hazardous waste)	Bilge oils from other navigation	MARPOL Annex I waste from vessels	100 to 1,000 tonnes	—	Treat using oily water separator if en route, else retain on board for subsequent discharge to dedicated vessels or port waste reception facilities.	

(adapted from South Stream Transport B.V. 2014)

And then, there is another example from the Pipeline project. You can see here, how they are adopting it, wastes, how they are dealing with the waste. So, what is the waste code? What is the typology? What is the description, or from where the source is coming? Was the quantity of the source and then potentially management, how they are going to handle it? And what kind of facilities do they have?

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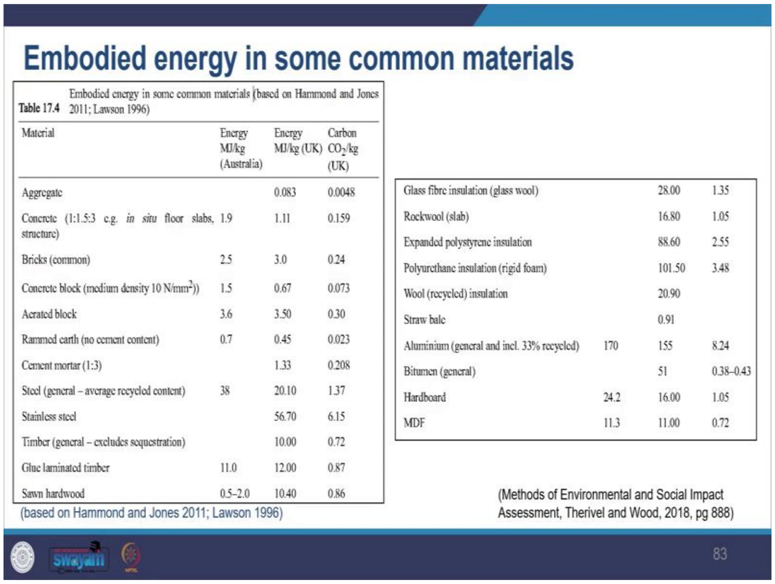


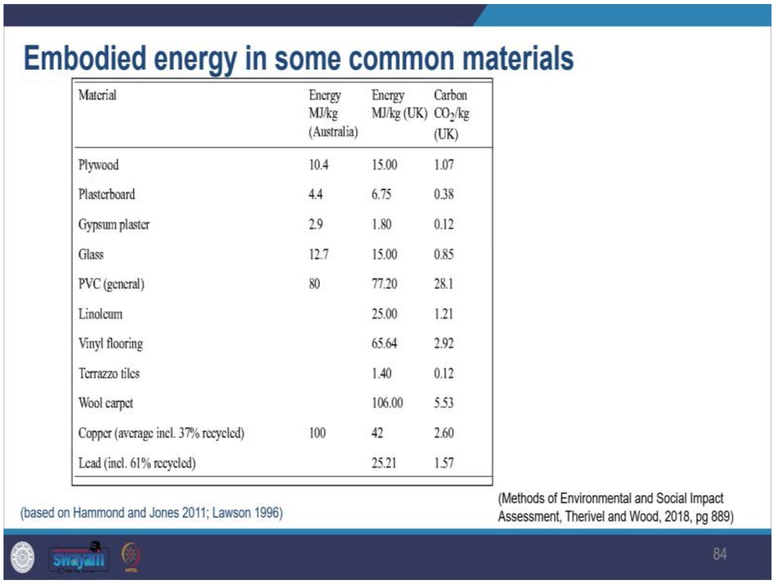
Embodied energy in some common materials

Table 17.4 Embodied energy in some common materials (based on Hammond and Jones 2011; Lawson 1996)

Material	Energy MJ/kg (Australia)	Energy MJ/kg (UK)	Carbon CO_2/kg (UK)
Aggregate		0.083	0.0048
Concrete (1:1.5:3 e.g. *in situ* floor slabs, structure)	1.9	1.11	0.159
Bricks (common)	2.5	3.0	0.24
Concrete block (medium density 10 N/mm^2)	1.5	0.67	0.073
Aerated block	3.6	3.50	0.30
Rammed earth (no cement content)	0.7	0.45	0.023
Cement mortar (1:3)		1.33	0.208
Steel (general – average recycled content)	38	20.10	1.37
Stainless steel		56.70	6.15
Timber (general – excludes sequestration)		10.00	0.72
Glue laminated timber	11.0	12.00	0.87
Sawn hardwood	0.5–2.0	10.40	0.86
Glass fibre insulation (glass wool)		28.00	1.35
Rockwool (slab)		16.80	1.05
Expanded polystyrene insulation		88.60	2.55
Polyurethane insulation (rigid foam)		101.50	3.48
Wool (recycled) insulation		20.90	
Straw bale		0.91	
Aluminium (general and incl. 33% recycled)	170	155	8.24
Bitumen (general)		51	0.38–0.43
Hardboard	24.2	16.00	1.05
MDF	11.3	11.00	0.72

(based on Hammond and Jones 2011; Lawson 1996)

(Methods of Environmental and Social Impact Assessment, Therivel and Wood, 2018, pg 888)



Material	Energy MJ/kg (Australia)	Energy MJ/kg (UK)	Carbon CO_2/kg (UK)
Plywood	10.4	15.00	1.07
Plasterboard	4.4	6.75	0.38
Gypsum plaster	2.9	1.80	0.12
Glass	12.7	15.00	0.85
PVC (general)	80	77.20	28.1
Linoleum		25.00	1.21
Vinyl flooring		65.64	2.92
Terrazzo tiles		1.40	0.12
Wool carpet		106.00	5.53
Copper (average incl. 37% recycled)	100	42	2.60
Lead (incl. 61% recycled)		25.21	1.57

Similarly, you can see another example of where they are using documenting the embodied energy so that they could understand the resource efficiency well, so you can see here how with material and each material, how is the energy, embodied energy is taken care of in various country context.

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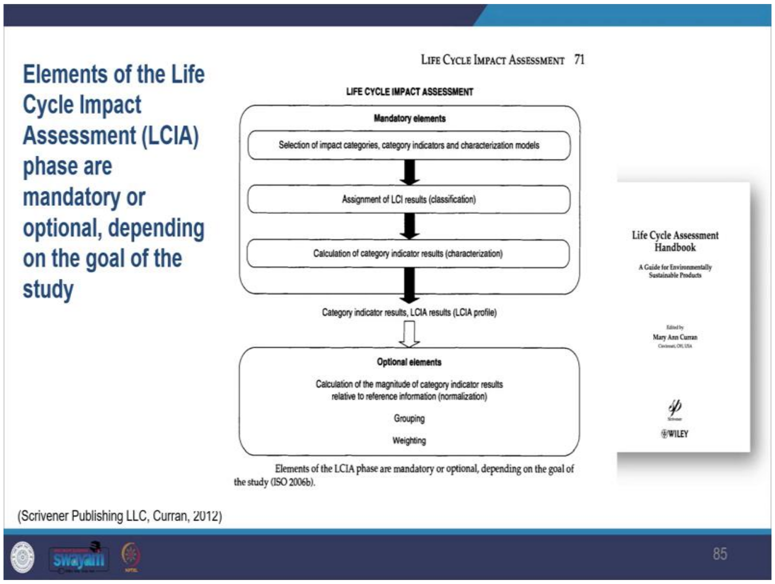

So I have just snipped another life cycle impact assessment for you, from the lifecycle assessment handbook. So, here you can see what is the process involved. And like, you will see what kind of mandatory elements are there. So selection of impact categories, category indicators, categorization of the models you are going to use? And then, assignment of lifecycle impact results, how do you classify them? You look at their significance at that time, and then calculation of category indicator results.

So, how you are going to see the indicator based on the classification? And then, based on that, how do you group and weigh it? So, we did discuss about grouping and weighting. So, when you classify that, and then you see whether it is falling and the very high impact or low impact on what weightage you give to each of those kinds of impact, which are happening. So, that was about the prediction.

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Now, moving on to the Mitigation aspect. So, resource efficiency is said to be best handled in the initial stage of EIA. And especially when you are dealing with all the alternatives, like where the project should be located, where the resource efficiency can be made at its best. And then, also when you are dealing with the design, what materials to deal with, how the technology would be there. So, that is the level where you handle the resource efficiency.

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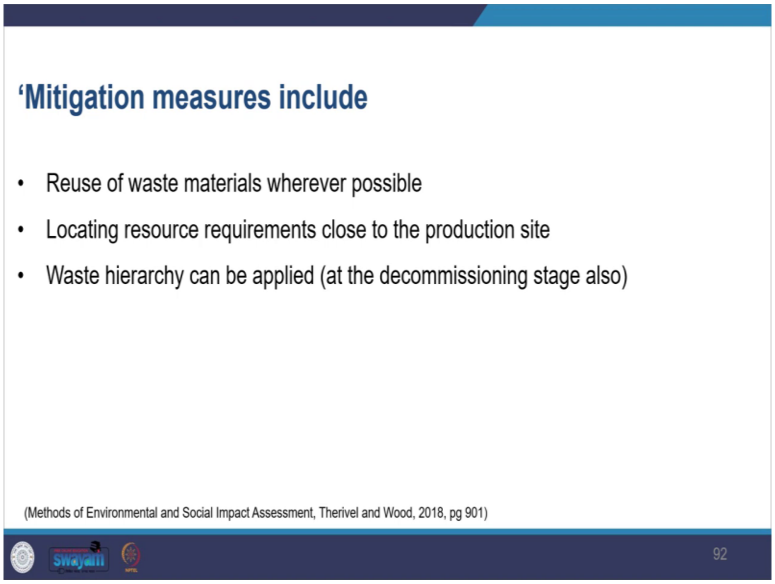

So, while you are doing it, as a developer or the project designer, you need to look at how what materials you are using and can there is less material, can achieve efficiency, sufficiency, or not. What do you need to look at and whether the project could use fewer lands and all the resources, can you work on the lesser land? Can you work in a more energy-efficient manner by the use of technology?

Can you use materials which are less have less embodied energy? And then how do you handle the waste product? And how do you look at the water-efficient technology? And how do you have the various techniques to recycle the resources, the water resource, the waste, all that you need to look at?

So, when you are doing the mitigation, you need to see all these again, all the concepts that you saw, how you are taking care of all those things. So, when you improve technology, you can maximize the efficiency of the resource and you can also minimize the pollution. So, all the concepts of reuse, recycle, all that would come here, and your mitigation measure. So, now looking at that was very briefly on the mitigation point.

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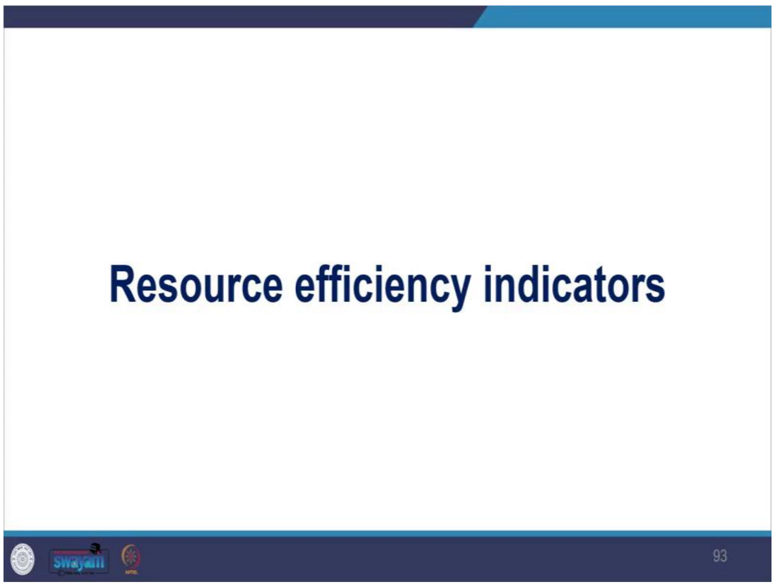

Now moving on to the resource efficiency indicator.

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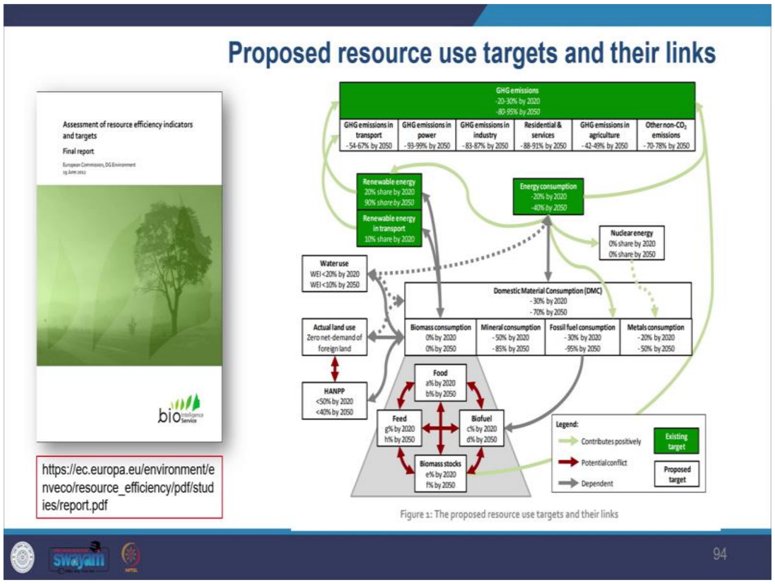

So here, I have taken this from the assessment of resource efficiency indicators and targets. So, they have given you the link, you can download how it gives you a complete idea about various concepts, and also the indicator, and then how you take care of it, or the resource efficiency part here. So, you see that in the initial week, the first week of our lecture, we looked at the environmental status. So, while we were dealing with the environmental status, we had all the global targets. So, resource efficiency also helps us to connect with the global targets.

So, here you can see that how they have greenhouse gas emissions on top and how data reduce intend to reduce by 20 to 30 percent by 2020, and 80 to 95 percent by 2050. And then how it is translated into the use of efficient resource usage. So, water usage, actual land use. So, all that, how they are looking at the domestic material consumption at different context level. So, through biomass consumption, mineral consumption, fossil fuel, metal consumption, and nuclear energy, you can see how it is being dealt with.

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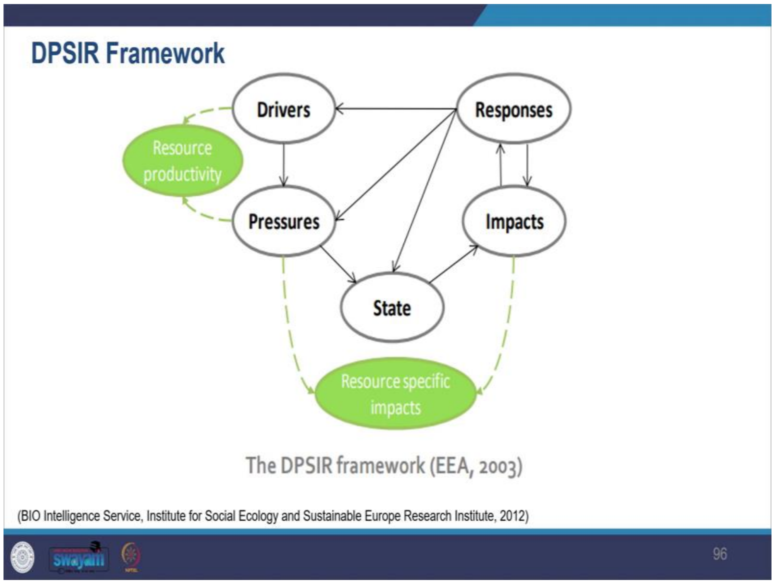

And then they also came up with the DPSIR framework. So, which are the drivers, pressure, state, impact, and response framework? So, we have studied about drivers, pressures, and states. So, there is this framework, which, in this, you try to analyze, what are the key drivers of the resources which you are going to use, and then the type of pressures exerted because of what kind of resource you are going to use, what kind of pressure will be exerted on the natural resource, and the natural environment throughout the lifecycle of these of the product stages.

And then what is the state of the ecosystem in which you are dealing with whether it is already stressed or it has scope for further development that also you need to look into, and then what kind of impact it will have and then what kind of response it will have in return. And then what kind of policy interventions you are going to take, improve in terms of productivity, and then how you are going to deal with specific impacts. So, it also provides you with the DPSIR framework, how to deal with this, and how to understand with.

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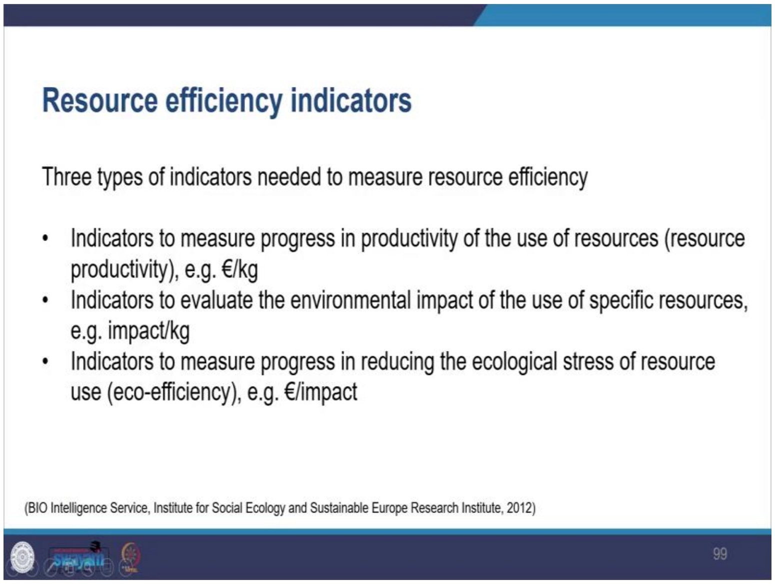

And then you are you also have this particular resource. The report also gives you the indicators. So, you have a resource productivity indicator, and looking at what is this? Resource productivity indicators are derived from the relationship between drivers and pressures. So, like water and water is the water and what is the water consumption per capita? So, that is what you look at water consumption per capita, when you are looking at resource productivity indicators, and then you have a resource-specific impact.

So, this is another term that is used. So, you can calculate based on the relationship between pressure and impact. So, for example, greenhouse gas emissions per unit of primary energy supply. So, as per the energy supply, how much are the greenhouse gas emissions, this will help you to understand resource-specific impacts.

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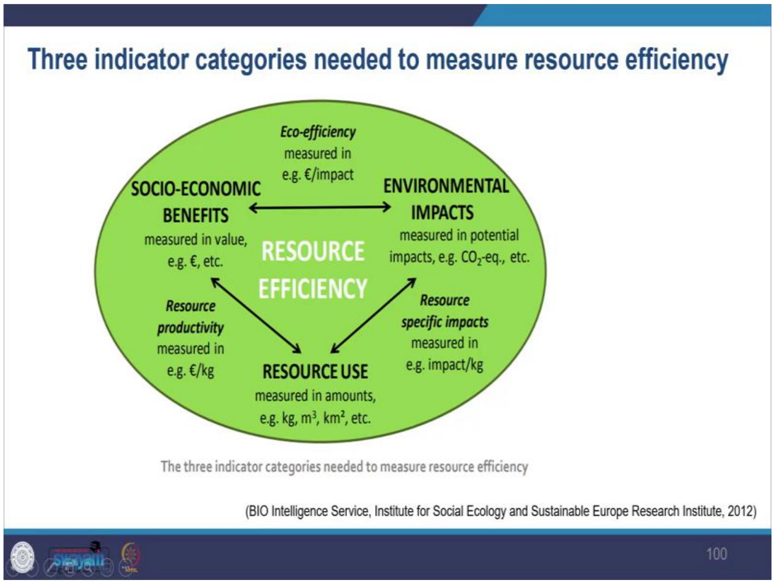

So, what resource you are using, and what kind of impact it will have? So, here you can see again, the resource efficiency indicator, indicates, you have they have developed a thematic strategy for the sustainable use of natural resources, where you have three types of indicators, that are used for measuring resource efficiency. So, you can see indicators to measure the productivity of the use of resources.

Like resource productivity in terms of what economic value is given per kg and then an indicator to evaluate the environmental impact of the use of specific resources, when you have indicators to measure progress in reducing the ecological stress of resource use, like cost for impact. So, if you look at that eco-efficiency, how do you attain that? So, you see that three indicators category, which are used to measure resource efficiency, you see the socio-economic benefits and environmental impacts and resource use, how they are being used at your place.

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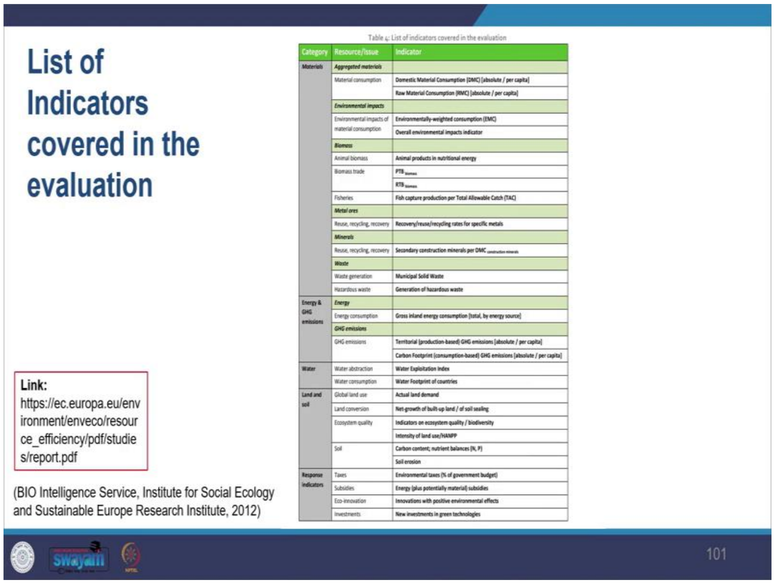

Table 4: List of indicators covered in the evaluation

Category	Resource/Issue	Indicator
Materials	*Aggregated materials*	
	Material consumption	Domestic Material Consumption (DMC) [absolute / per capita]
		Raw Material Consumption (RMC) [absolute / per capita]
	Environmental impacts	
	Environmental impacts of material consumption	Environmentally-weighted consumption (EMC)
		Overall environmental impacts indicator
	Biomass	
	Animal biomass	Animal products in nutritional energy
	Biomass trade	$PTB_{biomass}$
		$RTB_{biomass}$
	Fisheries	Fish capture production per Total Allowable Catch (TAC)
	Metal ores	
	Reuse, recycling, recovery	Recovery/reuse/recycling rates for specific metals
	Minerals	
	Reuse, recycling, recovery	Secondary construction minerals per $DMC_{construction\ minerals}$
	Waste	
	Waste generation	Municipal Solid Waste
	Hazardous waste	Generation of hazardous waste
Energy & GHG emissions	*Energy*	
	Energy consumption	Gross inland energy consumption [total, by energy source]
	GHG emissions	
	GHG emissions	Territorial (production-based) GHG emissions [absolute / per capita]
		Carbon Footprint (consumption-based) GHG emissions [absolute / per capita]
Water	Water abstraction	Water Exploitation Index
	Water consumption	Water Footprint of countries
Land and soil	Global land use	Actual land demand
	Land conversion	Net-growth of built-up land / of soil sealing
	Ecosystem quality	Indicators on ecosystem quality / biodiversity
		Intensity of land use/HANPP
	Soil	Carbon content; nutrient balances (N, P)
		Soil erosion
Response indicators	Taxes	Environmental taxes (% of government budget)
	Subsidies	Energy (plus potentially material) subsidies
	Eco-innovation	Innovations with positive environmental effects
	Investments	New investments in green technologies

Further, this report also gives you a list of indicators that are used for evaluation purposes. So, again, you can see the category material energy and greenhouse gas emission, water, land, and soil response indicators. So, you can see resource issues. Resource what has been used under the material, the range of resources, and then how you use the indicator. So, there are certain examples of indicators here.

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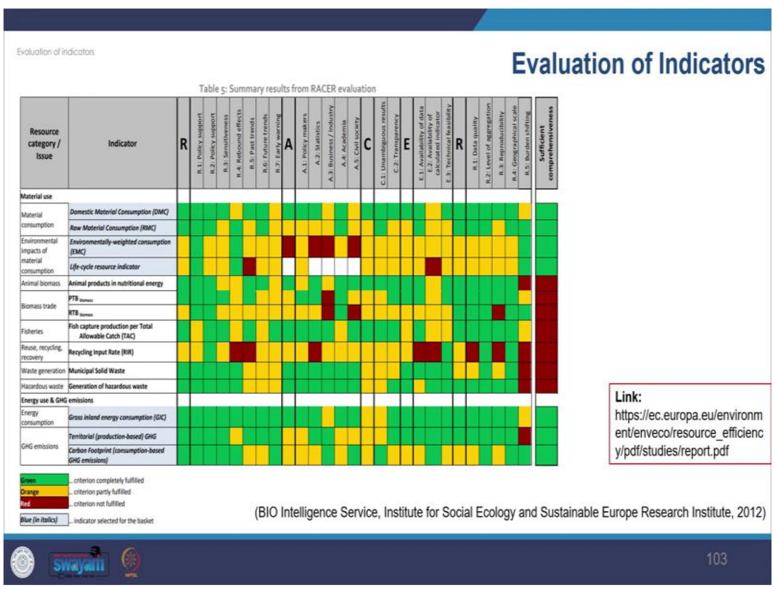

For domestic material consumption, absolute per capita, raw material consumption, like whatever absolute per capita environmental weight consumption, EMC, overall environmental impacts indicator, then for the biomass also you have similarly, you can see for the metal also recovery use, recycle rates of specific metals. So, all those indicators are given, which might help you look at how efficiently those resources are used.

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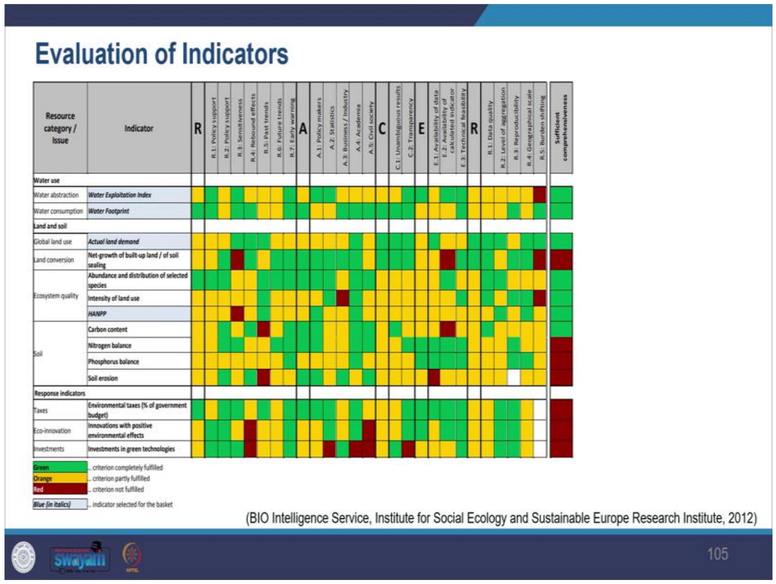

And then, you can look at another example, here taken from the same report. So, evaluation of indicators, so, how do you evaluate those indicators? So, you might be looking at all these, like how it all the resource category and what issues you are dealing with, and then what is the indicator, as you saw in the previous table, and then how you are going to take care of it. Like through the policy support, or sensitiveness, rebound effects past trends, future trends, early warnings, and how you are going to handle that.

And then, you can see, in this example, how they are looking at the resource efficiency, the green criteria completely fulfilled within the policy support within the sensitiveness. So, all the green would show the matrix you can prepare. Orange criteria, partially fulfilled, criteria do not fulfill all those red areas. So, this is how you can even depict your findings for resource efficiency.

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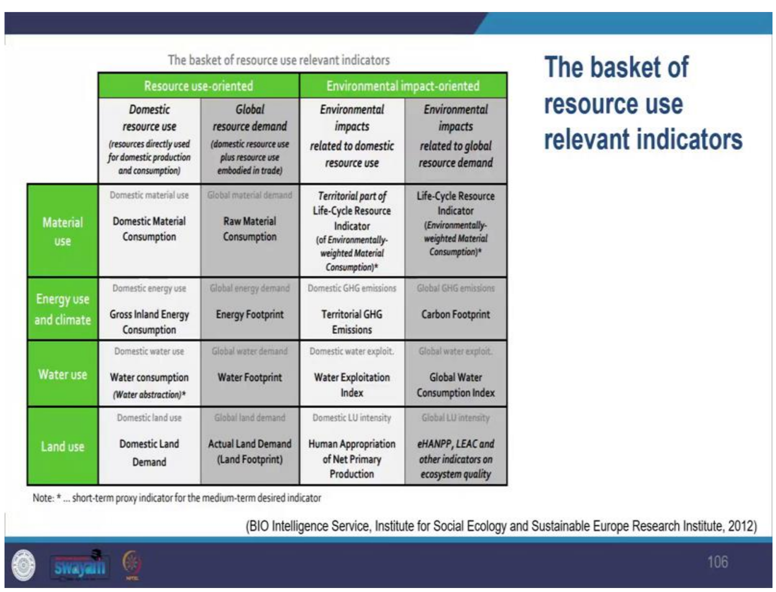

And you also have resource use relevant indicators, a basket of resource use indicators. So, you see material use, energy use, water use, and land use. And then, in terms of resource use, you look at the domestic resource use, global resource demand, you look at that, and then kind of environmental impact, which it might have at the domestic level and the global level. So, you look at this matrix here. So, you look at the material and domestic resource use, domestic material consumption, and how it is.

So by the standards and your contextual commitment, as per the country commitment, you are going to look at that, what is the raw material consumption rates and so on, and what is the energy footprint, what is the water footprint, what is the actual land demand, land footprints, and so on, for a resource on your intent.

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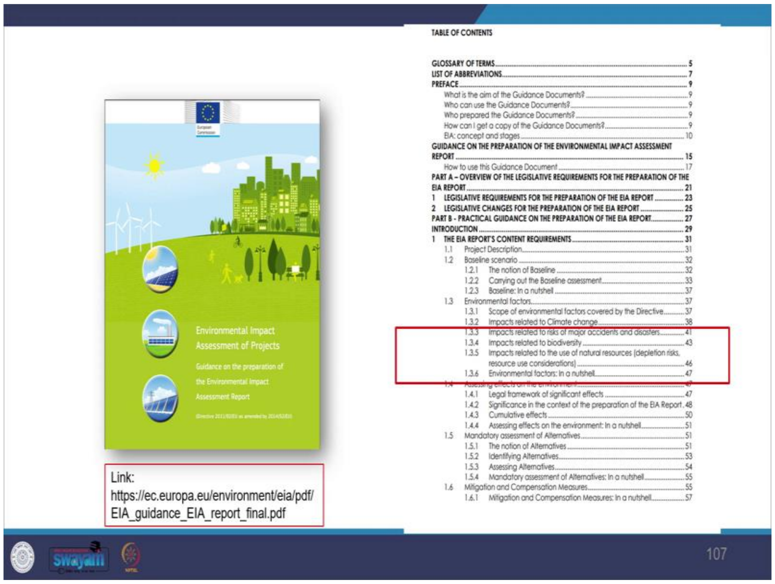

So, there is another guideline, that is available for environmental impact assessment as a project, I have given you the link here also you can see they have inbuilt and under, like try to handle points number 1, point 3, point 5, where you look at impact related to use of natural resources. So, there they have dealt with it.

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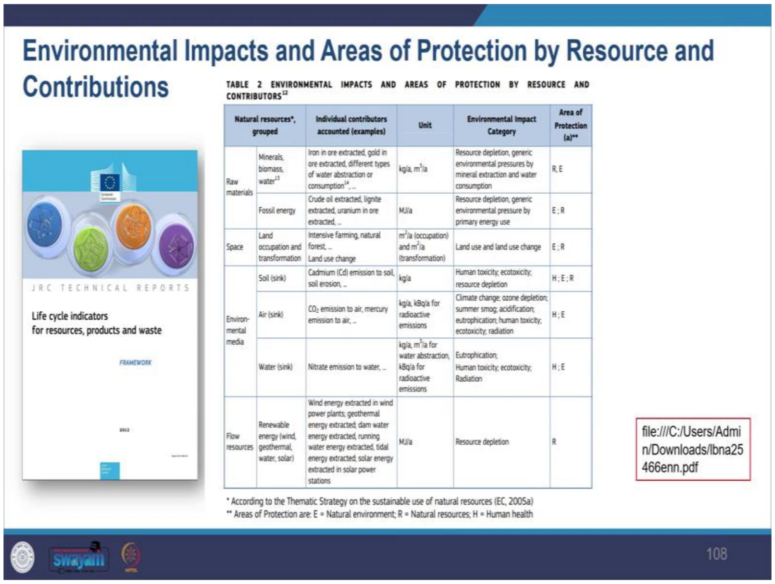

TABLE 2 ENVIRONMENTAL IMPACTS AND AREAS OF PROTECTION BY RESOURCE AND CONTRIBUTORS[12]

Natural resources*, grouped		Individual contributors accounted (examples)	Unit	Environmental Impact Category	Area of Protection (a)**
Raw materials	Minerals, biomass, water[13]	Iron in ore extracted, gold in ore extracted, different types of water abstraction or consumption[14], ...	kg/a, m^3/a	Resource depletion, generic environmental pressures by mineral extraction and water consumption	R, E
	Fossil energy	Crude oil extracted, lignite extracted, uranium in ore extracted, ...	MJ/a	Resource depletion, generic environmental pressure by primary energy use	E ; R
Space	Land occupation and transformation	Intensive farming, natural forest, ... Land use change	m^2/a (occupation) and m^2/a (transformation)	Land use and land use change	E ; R
Environ-mental media	Soil (sink)	Cadmium (Cd) emission to soil, soil erosion, ...	kg/a	Human toxicity; ecotoxicity; resource depletion	H ; E ; R
	Air (sink)	CO_2 emission to air, mercury emission to air, ...	kg/a, kBq/a for radioactive emissions	Climate change; ozone depletion; summer smog; acidification; eutrophication; human toxicity; ecotoxicity; radiation	H ; E
	Water (sink)	Nitrate emission to water, ...	kg/a, m^3/a for water abstraction, kBq/a for radioactive emissions	Eutrophication; Human toxicity; ecotoxicity; Radiation	H ; E
Flow resources	Renewable energy (wind, geothermal, water, solar)	Wind energy extracted in wind power plants; geothermal energy extracted; dam water energy extracted, running water energy extracted, tidal energy extracted; solar energy extracted in solar power stations	MJ/a	Resource depletion	R

* According to the Thematic Strategy on the sustainable use of natural resources (EC, 2005a)
** Areas of Protection are: E = Natural environment; R = Natural resources; H = Human health

There is another report, which you can refer to lifecycle indicators for resource production waste. Here, again, you can look at environmental impacts and areas of protection by resource and contributors. So, you again, see raw materials space, environmental media, flow resources, how those resources are there, individual contributors accounted, from where that is coming, and then what kind of consumption is there. And what kind of impact is there and what kind of intervention has to be taken for the protection.

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So as you can see, there is another available report, which you can refer, to land and ecosystem accounts for Europe towards geospatial environmental accounting. So, that is it.

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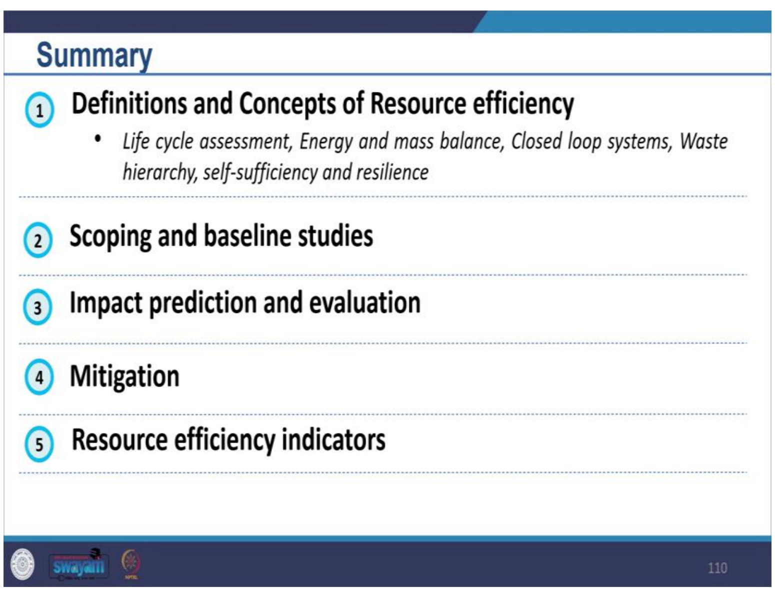

So, summarizing what we cover today. So, we looked at the definitions and concepts of resource efficiency, where we familiarized ourselves with different concepts. Then we looked at what we had undertaken during the scoping and baseline studies. And then we looked at impact prediction and evaluation, for which we also looked at several, guidelines and examples which are there in the later part.

Then we also looked at what we do in the mitigation and these are very much aligned with the definition and concepts that you learned. So, that fits into the mitigation aspect. Then, we looked at resource efficiency indicators like what are the indicators I used and the process in the domain.

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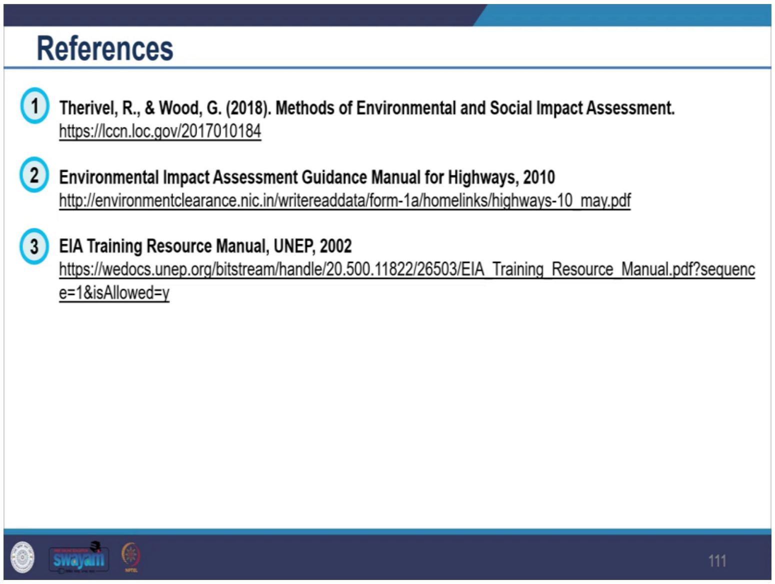

So, that was all for today and these were the references that we used for this particular session.

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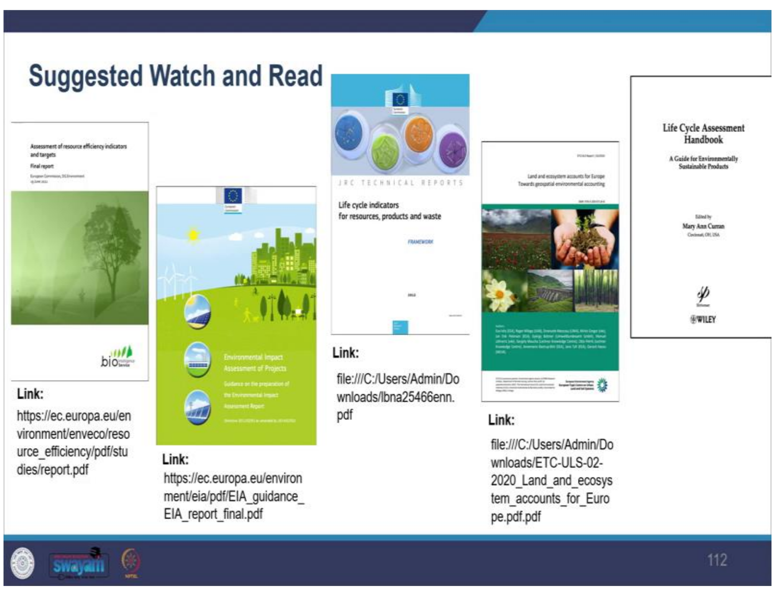

And further, you can look into all these reports. The links have been provided to you. And winding up, please feel free to ask questions.

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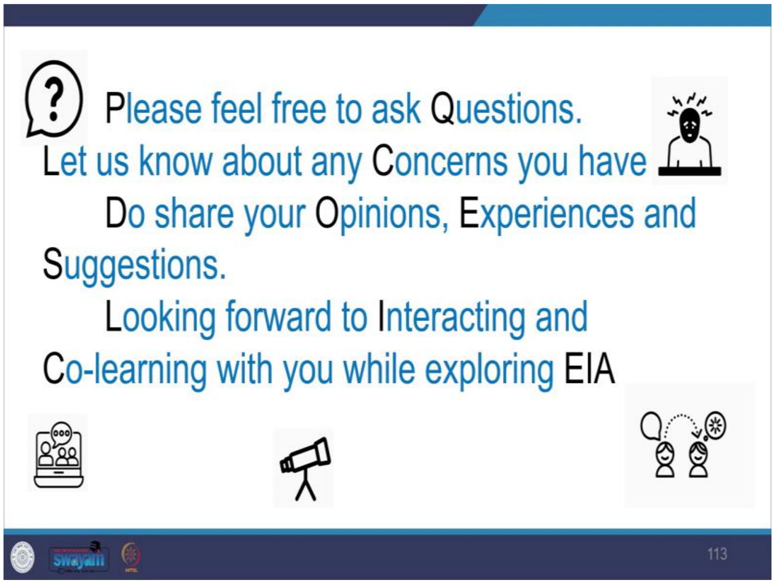

Let us know about any concerns you have. Do share your opinions, experiences, and suggestions looking forward to interacting and co-learning with you while exploring AI. Thank you.