Chemical Process Intensification
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Lec_08
Concept, Issues and Challenges

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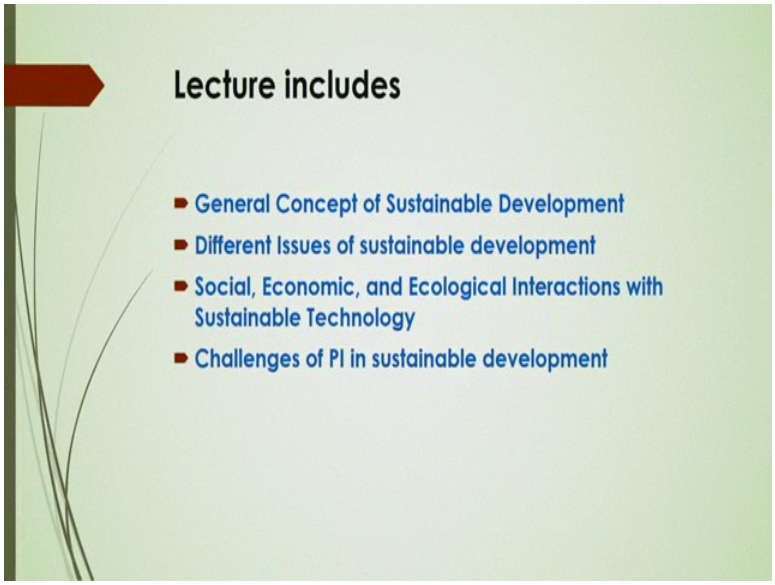

Welcome to massive open online course on Chemical Process Intensification. So, in this lecture under module 3 we will discuss something about concept, issues and challenges of process intensification in the sustainable development. This lecture includes general concept of sustainable development, social, economic and ecological interactions with the sustainable technology and different issues of sustainable development and challenges of process intensification in sustainable development.

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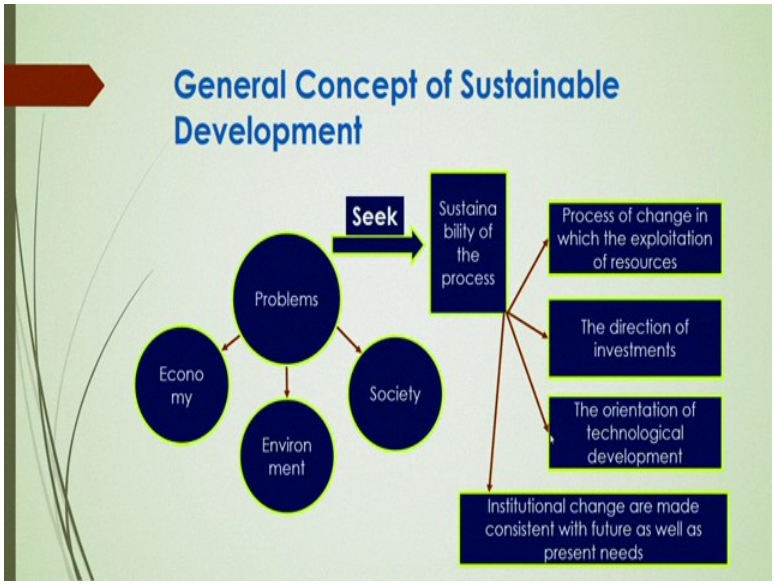

So, what under general concept of actually sustainable development? There are different issues of the sustainable development based on, you know that problems that has arises in the social benefit by this sustainable development. Generally, problems are sometimes economical problem, even environmental problem, some society cultural problems, so in that case there are these different issues of problems, generally, six sustainable development are based on the sustainable process by which this development can be procured.

And under the sustainable process development, the process actually, the change actually that system in which the, you know that the exploitation of the resources is being actually done. So, in that case based on the resources, how it should be managed and based on the process technology and how it can be actually, you know that minimize just by utilizing that resources, just by reducing the news materials there and also the investment is also one important based on the problems in economic.

And if you are developing the front, you know that process and based on that process that investment also required and if the process is more, you know that economic to minimize the waste in our, you know that resources what we are using and if we develop that process in a, you know certain way where that less investment can be done just by reducing the different, you know that process items are there like equipment, even, you know designing the plant with minimum species. Even reducing the number of, you know that processes, sometimes you have to integrate process in such a way that you can, you know the reduce the investment cost there.

Even that orientation of technological development is also important because how you are actually developing that process, that processes may be separately, you can handle or otherwise that more than one process that you can conjugate to each other and then you can indicate that processes, so that your investment will be less and by which you can get the more, you know that sustainable way to develop that process and even development will be sustainable development.

Also, institutional changes are made consistent with future as well as present needs, based on our, you know that present needs. Sometimes you know that whatever the people earlier used, nowadays that may not be, you know that demanding, maybe they are demanding more, you know, sophisticated instrument, sophisticated things are there, which will be more easier to handle or we can get the easier way to complete a certain process, certain you know that manner.

And also to, you know get our the thing in our society, more, you know that sophisticated way, so in that case you have to develop the process for the present need as well as, you know that demanding different types of, you know that fashionable items, so in that case fuser also it is demanding different, you know, sophisticated items or different things which will be needed for our daily life, even in our social requirement.

So in that case, sometimes you know that you have to procure some, you know training centre or some other things that, there where we can get this things more easier way by developing that process and so that is why policy should be made in such a way that, sometimes you have to make different research centres and other government initiative and policies, so that technology whatever it is coming, that should be actually, you know, utilise further processing for our daily life product.

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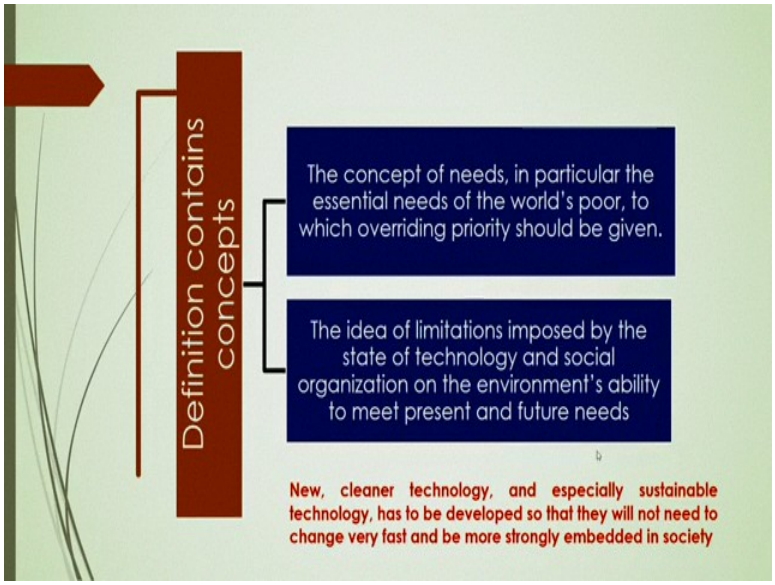

And also, that the different concept of that, you know sustainable developments. Now the concepts of needs, in particular the essential needs of the worlds poor people to be is that overriding priority should be given by that process development. So, in that case, whatever, you know that needs we presently, actually seek that, in that case maximum the worlds poor people are actually suffering in different way for the daily livings.

So, in that case, priority should be given to them, so that they can growing of and you know that they are coming to the streamline in our society. So, in that case your process development or sustainable development should be in that directions where that needs, the concept of needs is there, that whether it is for the rich people or for poor people, but there should be a balance.

So that is why the idea of limitations imposed by the state of technology and social organization on the environments ability to meet the present and future needs, so in that case, new, cleaner technology, special sustainable technology has to be developed, so that they will not need to change very fast and more strongly embedded in society.

So that definition that contains the concepts of needs in particular in the essential needs of the poor people to be is that overriding priority should be given. And the limitations imposed by the state of technology and the social organization on the environments at which ability to meet at present and, you know future need.

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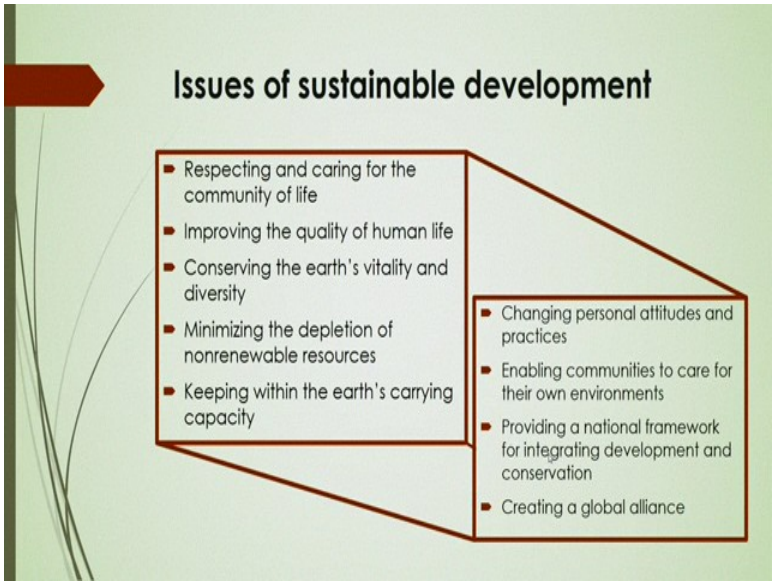

Now, what are the issues of that sustainable development? We are very much aware of that respectness and the caring for the community of our life and in that case, improving the quality of human life and conserving the earth's vitality and diversity, minimizing the depletion of, you know non-renewable resources and keeping within the earth's carrying capacity, so these are the different issues.

Even sometime changing the personal attitudes and, you know practices and enabling the communities to care for their own environments, providing a national framework for integrating development and conservations and also creating a, you know global alliance, these are the different issues for the sustainable development.

So, you have to concern about that whether that peoples are, you know wise enough for respecting and caring to each other and also the, you know that healthy community life should be developed there. And also, you know, you have to use the resources of this arts or natural resources in such a way that you have to conserving the earth's, you know vitality and the diversity and also you have to minimize the use of that non-renewable resources.

So, that depletion should be reduced their and keeping within the earths carrying capacity and sometimes the personal attitudes and the practices, sometimes are coming as issues for that sustainable development, sometimes the peoples are not allowed to, you know going that direction by, you know that by developing the sustainable process and using that process for getting the greener technology, there are several issues, there may be a political issues,

personal attitudes and other things, several other you know that personal things are coming, so that sometimes the sustainable development are, you know hindering.

So that is why you to take care of those things also and enable communities to care for their own environment also, because if you are developing any process and if you implement that process for to get the output or produce that product in our daily life with that process gives you the, you know that greener process or not, is there any hazardous materials are produced during that product or not and those hazardous materials how you are actually managing?

Whether it will be wasted to the environment and it will be keeping to the open environment or not, that may be health issues, so that thing should also be, you know considered during that sustainable development. And also, by providing a national framework of integrating development and conservation, very interesting that, in that case, you have to develop the process in such a way that, that by reducing the investment and you can do it just by integrating the process.

More than two process you can, you know use in one, you know unit and in that case, whatever suppose energy is consumed that can be, of course used for that particular process, whatever energy is wasted that energy should be used for other purposes, other processes, so in that case you have to integrate the process in such a way that, the energy wastage whatever it is there should be reused for other purposes.

And also creating a global alliances, of course you have to collaborate with the global people or other countries, so that whatever their technology and our technology, whether it is mismatching are whether we are lagging or their actually in higher versions or not, so all those things to be, you know that alliance should be required for that, so that we can equally, you know in label we can growing of as per worlds they are doing.

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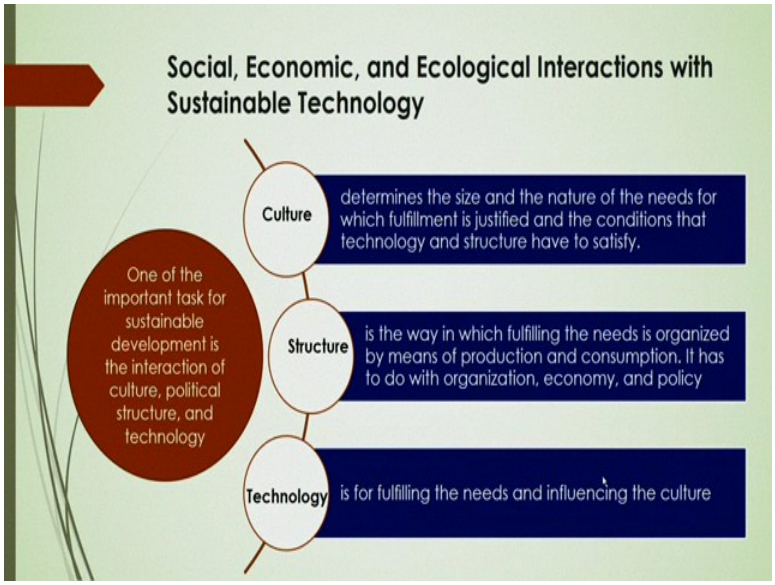

So, these other issues and also some interactions with the sustainable development with you know that the social, economic and ecological manner. One of the important tasks for sustainable development is the interaction of culture, political structure and technology, this other three important points there, so interaction in culture, political structure and technology.

Now culture that determine the size and nature of the needs, for which fulfilment is justified and the conditions that technology and structure have to satisfy. So, you have to aware of that culture, their size, that means community and what are their needs? What are their demanding and the what type of actually, those peoples they are actually, you know interacting to each other how they are interacting to the other parts of the country and other cultures also, other people and how they are actually interacting to each other.

So that should be actually, you know taken care for the fulfilment of this, you know sustainable development and the conditions the technology and structure have to satisfy there. And a structure is the way in which fulfilling the needs is organized by means of production and consumption and it has to do with organization, economy and policy.

These other things that whenever you are developing any process, that process should be based on the needs, that is, if you do not have needs than process should not be developed. So, you have to make a structure in such a way that based on the needs you are developing the process and you have to make your organization and that organization will follow a certain policy and based on that policy, your production and consumption should be, you

know that equally maintained or managed and it has to do by the organization and by the economic way and by the policy.

So, the structure should be developed in such a way that should be a managing, well management of that process, the organization, economy and policy, so that you are sustainable development will be reached up to a certain level and which will be compatible with the global scenario. So, the technology is for fulfilling the needs and influencing the culture.

So whenever you are developing any technology and based on the technology you are getting several products, now that several products whether it should be based on the cultural needs, based on some other, you know that requirements or not, now people of different culture, they are demand is different, so based on their demand may be the process to be develop, the sustainable development should be in such a way that their needs, based on their culture should be fully fulfilled and based on that technology.

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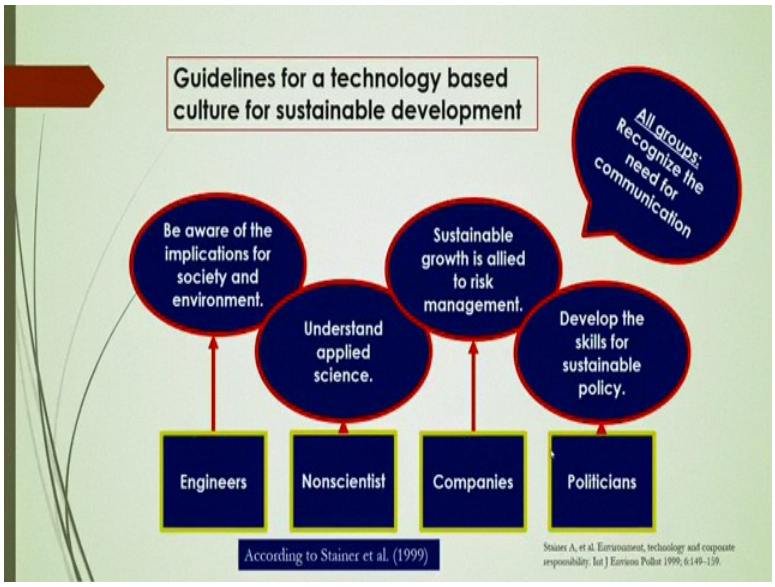

Now what are the different guidelines for the technology-based culture for sustainable development? You know that according to Stainer 1999, they have given some, you know that outline of that guidelines for a technology-based culture for the sustainable development. Now they have actually given four components, whose are actually interconnected to each other and they are understanding each other, whatever their role they are trust on each other and equally there, you know attitude utilising to develop that, you know society as a sustainable manner.

Now, what is that engineers what they are doing that? They are aware of the implication for the society and environment, so that is engineers because they know, you know that environment, how that environment will be polluted? How environment will be actually, you know that polluted? So, in that directions engineers they try to manage all those things based on the process development and also, they are trying all those things based on their implication of the society, so engineers are aware of those things, the society and environment, how that can be managed?

And non-scientist they are trying to understand the applied sciences, how engineers they are utilizing that science for the implications, for the development of that society and environment and companies what they are doing? They are doing that management in a sustainable way, so that the risk management should be less based on whatever the engineers and non-scientist are doing and also politicians they are developing the skills for the sustainable policy.

So based on that policy engineers are doing, non-scientist they are trying to understand and the companies they are helping for their management and by conjugating all this people and in a pan, so that based on the policy, everybody will learn and everybody will run and also engineers will there, engineers will be doing there, you know that society and environment development, non-scientist they are also taking part, companies also they will give the managements skill and politicians will to that policy.

So, all groups recognised the need for the communication, so in that case, engineers, non-scientist, companies, politicians all they are doing, they are, you know that portion, but how they will communicate, so it is required that commutations skill and also that how they will be actually cooperating to each other, so that should be considered for that sustainable development.

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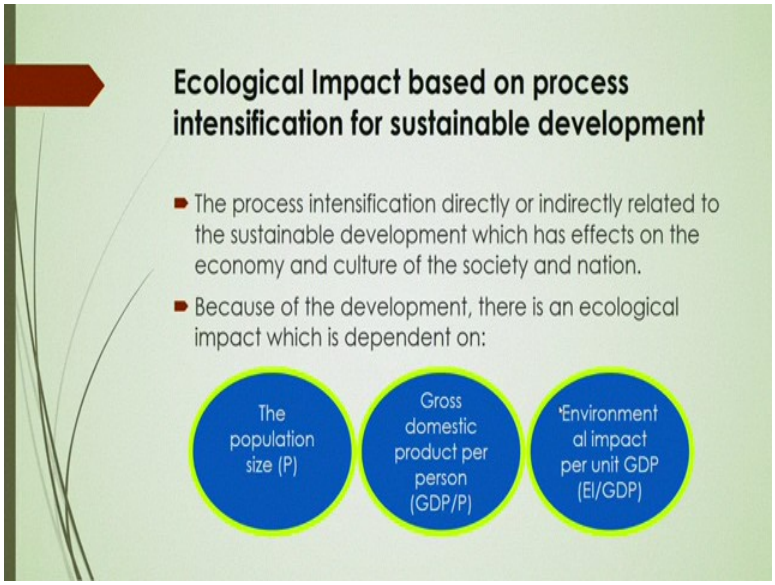

Now, ecological impact based on process intensification for sustainable development. Now in that case, you know very important things for the process intensification, that is directly and indirectly related to the sustainable development, which has effects on the economy and culture of the society and nation, because this development depends on the population size, depends upon gross domestic product per person, depends on environment, even environmental impact per unit GDP, that is gross domestic product.

So ecological impact that will be actually, you know that effected by the population and that, you know impact affected by the not only population that will be affected by the technology, whatever it is developed, because that technology will give you the gross domestic product and based on that population size and gross domestic product, that ecological impact will be assessed. So that is why the ecological impact will be depending upon the size of the population, the domestic product and the environmental impact factor based on that, you know gross domestic product there.

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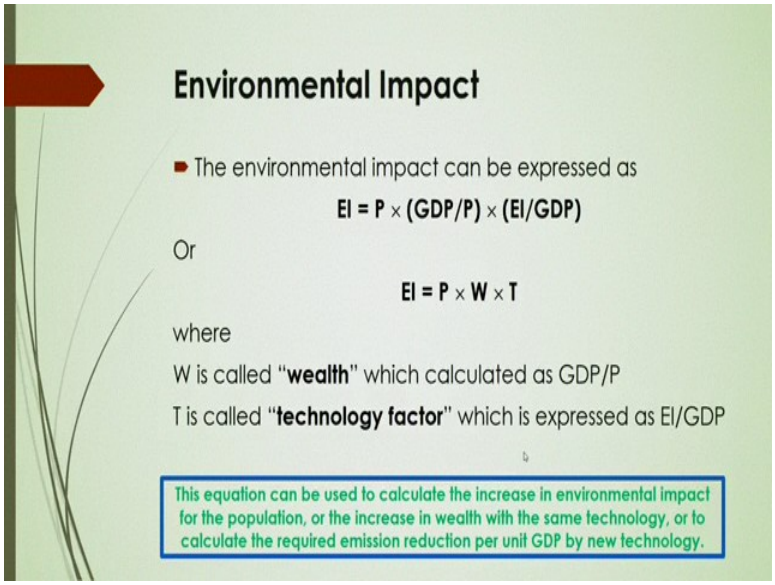

So, let us see how to calculate that environmental impact, the environmental impact can be expressed by, it is included by EI that should be equal to P into GDP by P into EI by GDP, so here EI is called the environmental impact, GDP is gross domestic product, P is the size of the population, so in that case environmental impact with P is equal to size of the population and wealth of the population which will be calculated as GDP per P, that means gross domestic product per person, so it is called wealth and also another important is called T, the T is called technology factor, which will be defined as that environmental impact per GDP, so it is called technology factor.

So environmental impact, that should be is equal to population size and wealth and technology factor. So, product of these three components will give you the environmental impact, so this equation can be used to calculate the increase in environmental impact for the population or the entries in wealth with the same technology or to calculate the required emission, reduction per unit GDP by new technology. So, whenever you are going to calculate this environmental impact, that you have to know the emission, reduction per unit GDP, and that can be obtained only by developing the process, developing the technology, so that is why this environmental impact directly related to that technology.

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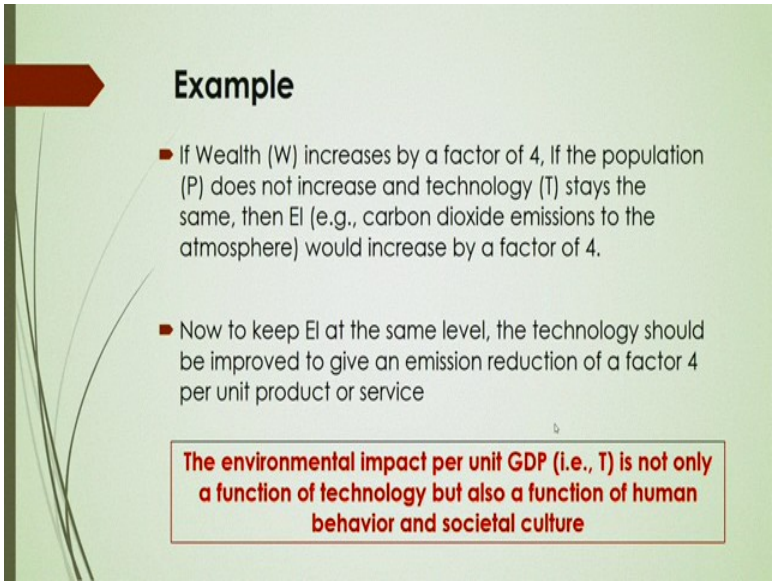

Example, now if wealth suppose increases by a factor of 4, if the population size is P and that does not increase and technology T stays remain same, then environmental impact that is called carbon dioxide emissions to the atmosphere, that is based on this carbon dioxide emissions, your environmental impact would increase by a factor of 4, see very interesting that we can calculate this environmental impact based on the carbon dioxide emissions to the atmosphere.

If suppose this carbon dioxide emission will be less and if you develop the process in such a way that, the emission will be less, so in that case, of course, that environmental impact will be changed, so if wealth increases by a factor 4, if the population P does not increase in technology, if it is same, suppose there is no technology develop and the same whatever existing technologies there, only wealth is increases by 4, so you environment impact will be increase by a factor of 4.

Now, if you keep this environmental impact same level, if you want to keep this environmental impact same level, the technology should be improved to give an emission reduction of a factor 4 per unit product of service. So, you have to develop the process in such a way that your emission reduction should be there of a factor of 4 per unit product to keep your environmental impact same, so that is why the environmental impact per unit GDP is not only a function of technology, but also a function of human behaviour and social culture.

See how it is related, first of all, you are developing the technology, so based on that the environmental impact will be there changing. Now if you are human behaviour is changing, social, you know that culture is changing based on which that, you know that environmental impact will also change because their emission of the carbon dioxide, behaviour whatever this, whether it is agitation or other things, maybe there would be destroying the technology, some other means, there are several other means that will be acting on that, so that there will be some change of environmental, you know that polluting the environment, in that case, you can say that environmental impact will be changing.

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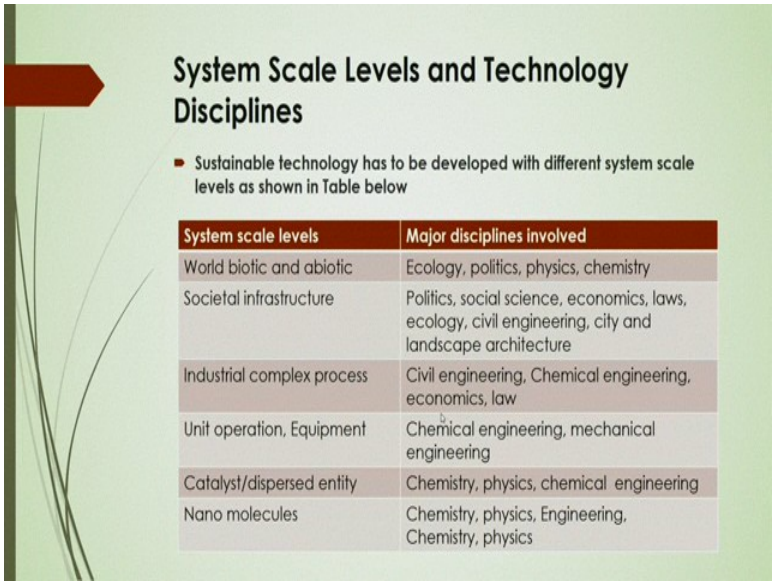

Now, what are the levels, different scale levels and the technology disciplines? So that you can get the sustainable technology for that different system scale levels. Now as per this, you know we can get the different types of system scale levels like, you know that world biotic and abiotic system, in that case major disciplines are involved like ecology, politics, physics and chemistry.

Societal infrastructure, like politics, social sciences, economics, laws, ecology, civil engineering, even city and landscape architecture are, all these things are actually societal infrastructure based on which you have to develop the sustainable technology to get your sustainable development.

Now industrial complex process, in that case you will see civil engineering, chemical engineering and economics, law, those are major disciplines that involved for these industrial complex processes, for unit operations equipment in that case disciplines are chemical

engineering, mechanical engineering, of course, the chemical engineering, they are several unit operations are there, like you know that distillation column is also one important unit operation.

Distillation for, you know refining oil that is in chemical engineering, operation is there, so that is, you know chemical engineering disciplines are involved for that sustainable development for that unit operations, if you develop that unit operation, like you know that distillation, not only, nowadays this distillation is coming, membrane distillation, you know, reactive distillation, extractive distillation, that is integrated systems are coming.

So, in that case the development of the process, intensifications of the process are there, so in that direction that chemical engineering, even mechanical engineering, they are developing different types of equipments, so based on which these sustainable developments are there. Now, even you know catalysts and dispersed entities our also very important parts for the process intensification, especially for the reaction systems.

So in that case synthesis of any organic or inorganic compounds, in that case chemistry, physics, chemical engineering they are, you know that involving for those synthesis or that, you know greener products, so in that case, catalysts that is, for you know, enhancing that reaction, even you know dispersed entity should be used or develop in such a way that based on that greener technology the sustainable development can be done.

Even nano molecules nowadays that nano molecules are coming, so physics, even chemistry, engineering, you know chemistry, physics, they are actually these disciplines are involving in research for this nano molecules and they are developing different nano catalyst, you know that nano materials, based on which they are actually, you know applying those nano materials, for different processes like nowadays adsorption processes. Nowadays, you know that waste water treatment, they are using that nano molecules, nano materials, for, you know that remove of various micro or nano level hazardous materials, which will be very beneficial for our health concerns.

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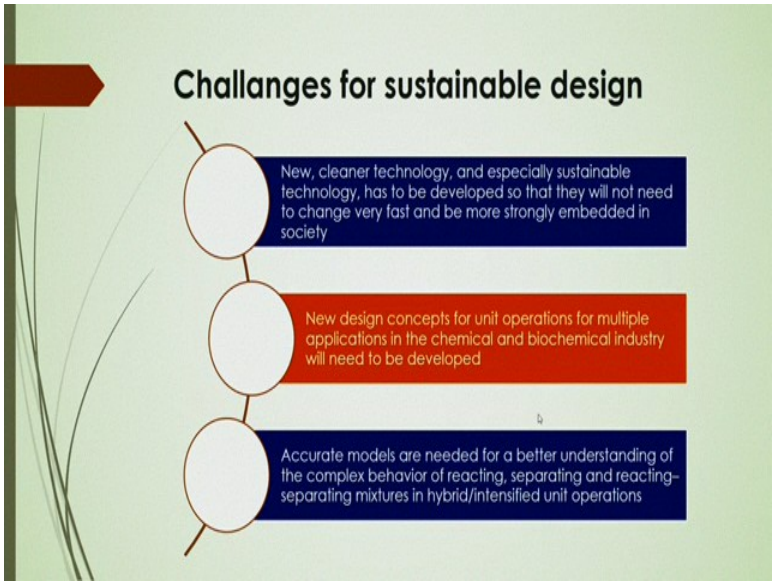

Now, what are the challenges for that sustainable design, there are several challenges nowadays are coming, how to, you know design that, you know, sustainable processes, so in that case, new cleaner technology, you know especially sustainable technology has to be developed, so that they will not need to change very fast and more strongly embedded in society.

So you have to develop the process in such a way that it should be long-lasting, not like that, you know that within a few days that, you know that technological not be, you know used and after that, after research, it is coming that, this technology is not suitable at all because this technology is giving several other hazardous by-products, so this technology will not be used for that, so your technology should be developed, so that it will be, you know that for long-term it will be useful and also, you know, sustainable.

New design concept should be developed for the unit operations for multiple applications in the chemical and biochemical industries and will need to be developed. In that case, you know that nowadays that, I told that extractive distillation, you know that reactive distillations, earlier reaction, distillation, they are separately done, but nowadays both the, you know operations will be simultaneously doing and whatever products is coming in a single unit, they are immediately that separated by that, you know that unit.

So in a single unit they are conjugating all the processes, so that the reducing the equipments, there, you dissing the, you know investment, they are reducing the chemicals whatever being used there and nowadays also faster way and you know that greener way that technologies

are coming, so that, that, you know that different unit operations in the chemical engineering and mechanical engineering they are procuring based on that concepts.

Now, accurate models are also to be needed for better understanding of the complex behaviour of the reacting, separating and you know reacting, separating mixtures, you know, hybrid or intensified unit operations. So, whenever you are developing that hybrid intensified units or integrated intensified unit or you are developing a process, so you have to understand the complex behaviour of that process because whenever you are going to integrate it, the complex it will be increased, so you have to understand the complexity of that process.

Now, to understand that capacity you have to use your understand the complexity based on your, you know that behaviour of the fluids, you know that properties of the fluids, pro phenomena of the fluids, pro phenomena of the materials, even different physical properties of the materials, how there actually interacting to each other? You know, suppose multiphase flow systems, gas, liquids and solids, three phases are interacting to each other, now in a certain system, there will be a frictional resistance whenever the process will be, you know that executed.

Now that frictional resistance is coming, based on not only that one and only individual faces, but the frictional resistance will come, even within the phases also, within the particles, within the, you know that drought, if the droplets are being formed from that liquid, liquid operations, so there you have to consider all these things.

How that droplets or how that bubbles, how that, you know particles will be, you know moving inside the reactor and how it will be homogenized, how it will be, you know distributing, based on the distribution, based on the flow pattern that all output or performance of the, you know process depending on. So, you have to understand the complex behaviour of that process in the hybrid intensified operations, so this is one of the important challenges for that sustainable design.

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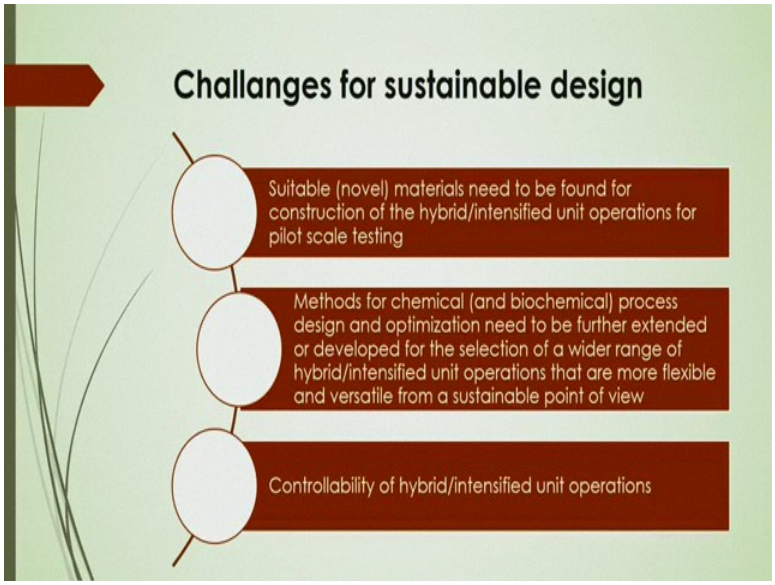

And also you know that suitable materials, sometimes to be, you know develop or you can synthesise for that particular hybrid or intensified unit operation for the pilot scale testing also, methods for chemical, even biochemical processes should be design and optimized and in that case, further extension or development for the selection of a wider range of, you know hybrid or intensified unit operations that are more flexible and versatile from a sustainable point of view should be considered.

And also controllability of hybrid or intensified unit operations also very important here, should also be considered for the sustainable design and it is very challenging that how to control that intensified unit, hybrid intensified unit, because, you know, whenever you are integrating the system that control also will be very difficult for that, so you have to develop, you have to design the system in such a way that there should be easier to control.

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Now challenges based on different development item, like you know that sustainable development item, like to provide for the needs of the poor water, food, clothing, local energy etc, now in that case challenges is greener way, so you have to produce the greener product for the, you know that needs of the poor, now you have to suppose that water is required for the very basic needs, now you have to purify the water in such a way that all the, you know that materials, that is hazardous materials should be, you know that separated.

Now that separation should be done in a hybrid way or single or easier way, so that the common people, poor people can easily, you know that use that process and it should be sustainable, so it is challengeable, so you have to develop the process that will be greener way, so that even if you are developing the process to give you or to have certain output that should be without hazardous material.

So fair distribution of wealth, power and knowledge is also the item for the sustainable development, in that case, the adaptation, non-disruptive to society should be the challenge for that, that case, you know that how you can distribute the product to the society and also whether that production be easily adoptable to the society or not.

So some products you are, you know that producing in such a way that, that peoples are not actually favourable to use that material or that product, so you have to produce that product in such a way that people should understand the basic things of that product, so that they can easily except those product, so adaptation of that product or that, you know knowledge of that particular product should be given to the people, so that they can easily except those product.

And also, that occupational health, the product should not be in such a way that, that will contain some, you know that hazardous material, unwanted materials, that will not be at all that, you know is required for that product, still sometimes it is being used to that product. Now sometimes some policies making in such a way that okay, there are huge, you know, populations, so how to manage all this, so you are mixing some other things with that, so the purity of that product will not be hampered. So long-term effects of the exposure to the chemicals should be known and acceptable, so there, you know that what are the chemicals that you are using that should not be hazardous.

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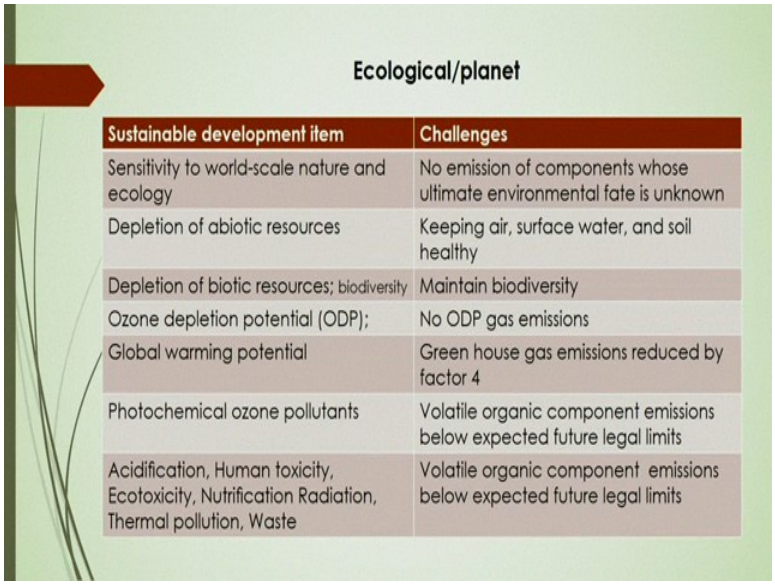

An another ecological or planets system, so in that case, the item for the sustainable development are sensibility to the world scale nature and ecology and in that case challenges are no emission of the components will be there and in that case ultimate environmental fate is unknown, so that is to be considered for the sustainable development and depletion of abiotic resources, in that case, the air should be clean and healthy and surface water should be clean and healthy and soil also, whatever should not be contaminated with the hazardous material, this is the challenges.

Depletion of biotic resources is called biodiversity, so you have to maintain the biodiversity level, so in that case, you should not, you know destroy that, you know microorganisms or organisms, whatever the different, you know animals it is called biodiversity that should not be actually destroyed. So, it is to be maintained in the particular level, so it is a challenge and also ozone depletion potential is also an important thing, no ODP gas emission should be

there, so that is challenge, global warming potential, greenhouse gas emission should be reduced, that is also challenged and it should be reduced by a factor 4.

Photochemical, you know that ozone pollutants are nowadays important, because there are so many processes intensification process are coming, where there, you know. Photochemical reactions are being actually done, so in that case, some volatile components are being emitted, below expected future are legal limits to be, you know that maintained so this are the challenge.

And acidification, human toxicity, eco-toxicity, nutrification radiation, thermal pollution, waste all those items also should be considered for the sustainable development, where organic whatever volatile components are coming with this, you know that processes like acidification, even you know that eco-toxicity, nutrification radiation process, so in that case, it should be, you know make limits as per World Health Organisation, so volatile organic components emission is should be, you know reduced to a certain expected legal limits.

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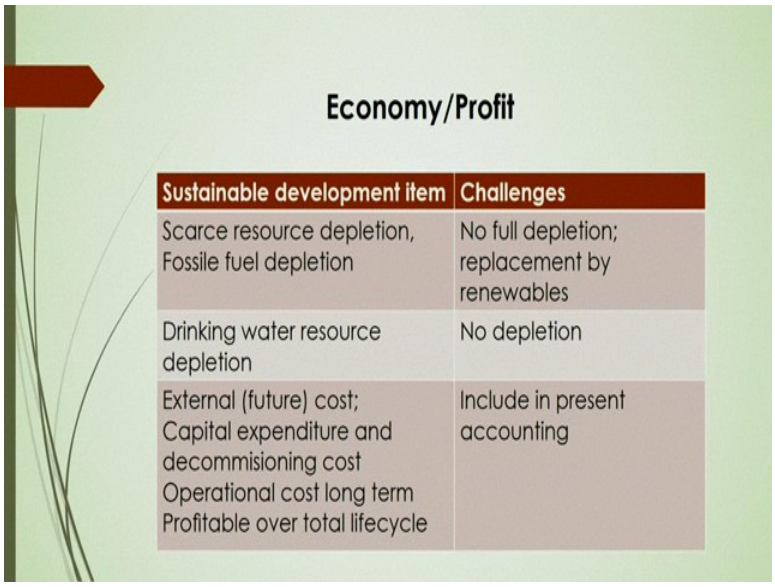

And also, you know scarce resource depletion, fossil fuel depletions, in that case challenges are no full depletion should be there, replacement by renewables should be there, so these are the challenges for this, you know, sustainable development, drinking water resources depletion there are several, you know issues are for this drinking water resources, sometimes that is not actually available in the society, so in that case, the depletion of that resource of drinking water should be minimized, so it is one of the important challenges.

Extra cost, capital expenditure, decommissioning cost, operational cost that is long-term, profitable over total life-cycle, so for this, you have to consider that economical way to develop that process, so that your capital expenditure or investment for that particular process to produce the products for our, you know society, so in that case, the external cost or other capital expenditure should be reduced for the.

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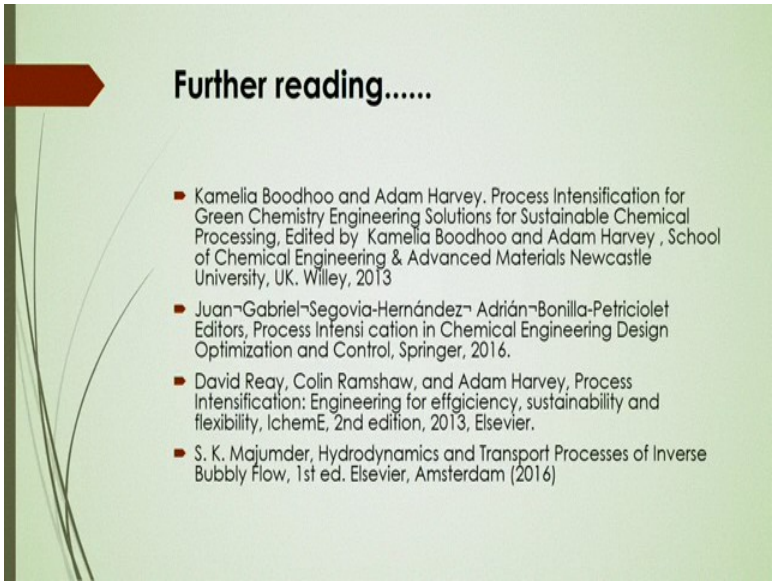

So, I think we have discussed something about that issues, challenges, even how actually that different, you know parts of the society they are interacting and they are taking part for the sustainable development, so I would suggest you go for further reading about the sustainable development, here in the slides some reference books are given. So, I think it will be helpful for your better understanding, so thank you for this lecture.