Leadership for India Inc: Practical Concepts and Constructs
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Week – 03
Leadership for Sustainable Growth
Lecture – 13
Resource Leadership

Hi Friends, welcome to the NPTEL course on Leadership for India Inc. Practical Concepts and Constructs. We are in week 3, discussing Leadership for Sustainable Growth. When we say growth, we are looking at not merely business growth which is sustainable, but also sustainability of the planet. In this lecture, we will consider Resource Leadership having considered technology leadership and climate leadership in the previous two lectures.

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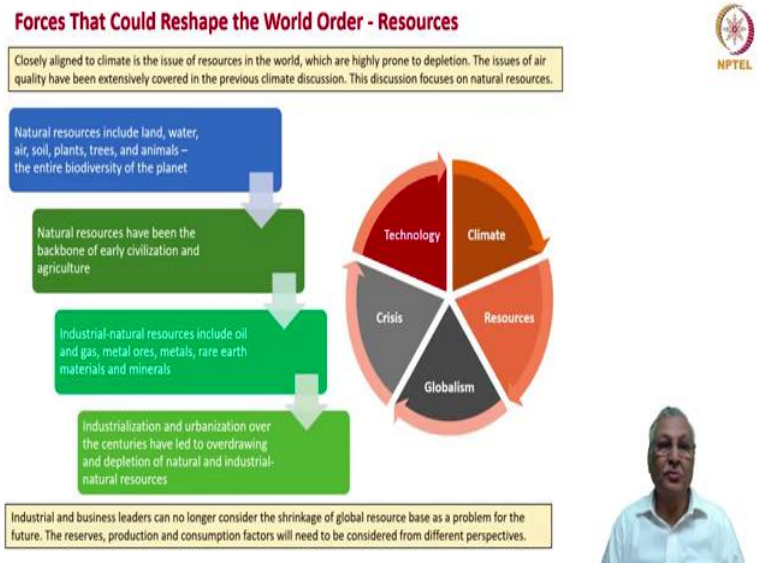

As I said, there are 5 forces which reshape and dictate the world order. Amongst these 5 factors, we are considering resources in this lecture. Without natural resources industrial activity cannot take place, not can economic activity take place. Natural resources include land, water, air, soil, plants, trees and animals, in fact, the entire biodiversity of the planet.

They have been the backbone of early civilization and agriculture. They have also been the key drivers for industrial development and growth. There are several industrial natural resources; oil, gas, metal ores, metals, rare earth materials and minerals are some of the prominent industrial natural resources.

Industrialization and urbanization over the centuries have led to overdrawing and depletion of these natural resources and also the industrial natural resources. Industrial and business leaders can no longer think that the issue of resource management and resource leadership is not an issue for the future. Time is now and immediate to focus on resource utilisation and see how the world can be saved from higher levels of resource profligacy; that is beset us.

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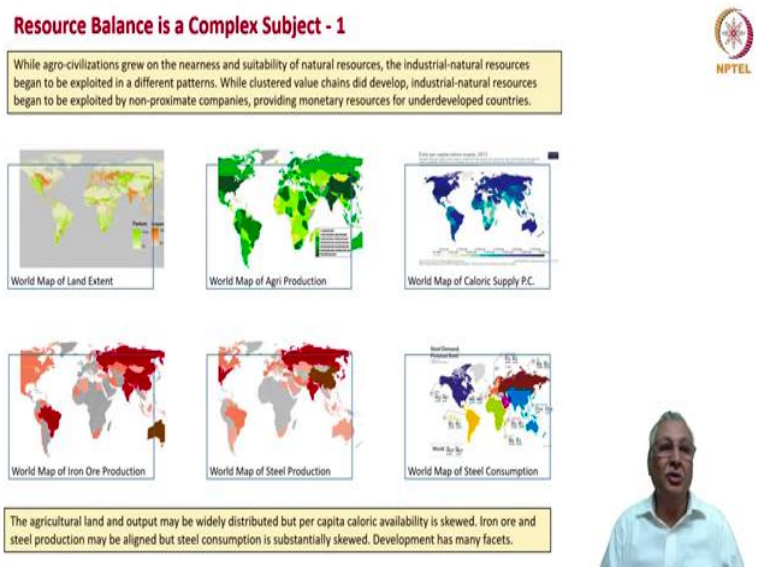

Resource balance is a complex subject. If you look at the world map of land extent, it is quite well distributed. If you look at the world map of Agri production with various shares of agricultural dominance and dependence, again you will see that the uniform distribution does not exist.

There are some countries which are pretty much agriculture oriented and there are some countries which are dependent on other countries for agricultural and food needs. If you look at the world map of caloric supply, you will find that all the countries which are agriculturally sustainable are not necessarily sustainable in terms of the caloric supply;

therefore, there is a skew there. If you look at the world map of iron ore production and if you look at the world map of steel production, you will find some kind of congruents.

But if you look at the usage of steel, you will find that there is a lot of dispersion; which means that natural resources occur in some places, they are utilised in some other places through industrial production, but they are consumed in much greater need and much greater scale in some other regions.

Therefore, there is a kind of huge global network and global value chain that determines how resources are available, how they are exploited and how they are used in final products and services which are consumed by population all over the world.

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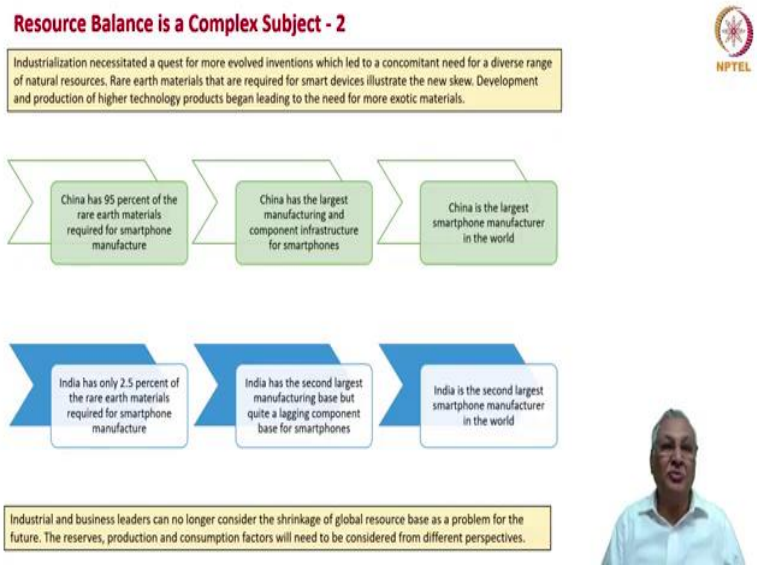

Resource balance is a complex subject, because the industrialization that has happened over the last few decades has led to an increased and exponential use of resources and those resources are rare resources. Let us take the example of smart devices. China has 95 percent of the rare earth materials that are required for smartphone.

China also has the largest manufacturing and component infrastructure for smartphones. And therefore, China is the largest smartphone manufacturer in the world and is able to supply the smartphones all over the world. India also has got the ability to manufacture smartphones and in fact, it is one of the largest markets for smartphones.

However, India has only 2.5 percent of the rare earth materials that are required for smartphone manufacturer. We have the second largest manufacturing base, but quite a lagging component base in terms of the key inert for smartphones.

India probably is the second largest smartphone manufacturer in the world. Probably, the second largest smartphone market in the world. However, the skew in terms of the integration towards the basic rare earth materials which are required for smartphones and the skew towards the consumption of the smartphones exist at two polarities.

There is therefore, the complexity of resource balance. We cannot consider the shrinkage of global resource base as a problem for the future. Similarly, countries cannot depend on importation of resources from some other countries to be able to hold up their manufacturing capabilities or market characteristics. Resource planning is therefore an analytical job and also a leadership challenge.

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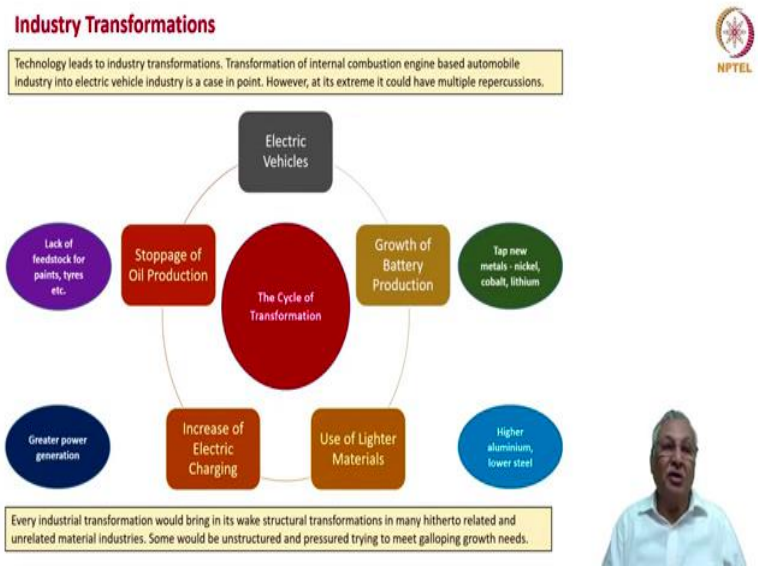

Industry transformations are linked to resource profiles. Let us take the example of electric vehicles. Everyone is agreed and we have discussed this in the previous lecture also that we need to move towards electric vehicles, because fossil fuels cause pollution and cause climate warming.

Now when electric vehicles are required in great numbers, battery production has to grow. Along with that use of lighter materials also has to go. And then the charging

infrastructure for electric vehicles has to come about, which means that there should be more power drawal all over the country, and this would lead finally, to the stoppage of oil production.

There would be collateral impacts as well as collateral drivers for these activities. To be able to increase battery production, we have to tap new metals; nickel, cobalt, lithium, to be able to sustain the battery production. In order to use lighter materials, we have to have higher levels of aluminium and lower steel and probably also have steel which has got better weight-strength properties.

We need to increase power generation, which cannot again be through fossil fuel usage, we have to have more renewable power. But when oil production is stopped we also have the loss of feedstock for paints, tyres and various other industrial chemicals and materials. Therefore, every industrial transformation has got several challenges related to resource availability and resource use which need to be harnessed.

They also create new issues and new problems for other industrial sectors which also need to be tackled. So one has to take a very holistic view of the cycle of transformation that happens in the industries. These transformations could be from fixed phones to cellular phones and from there to newer kinds of connectivity devices.

Similarly, from the automobiles conventional automobiles to electric automobiles. So whatever be the industry transformation, there will be some pluses there will be some negatives. There will be some supportive drivers, there would be some industries or segments which will be starved of inputs. This is the balance sheet one needs to draw out and decide how to make this balance sheet friendly for the society and friendly for the economy.

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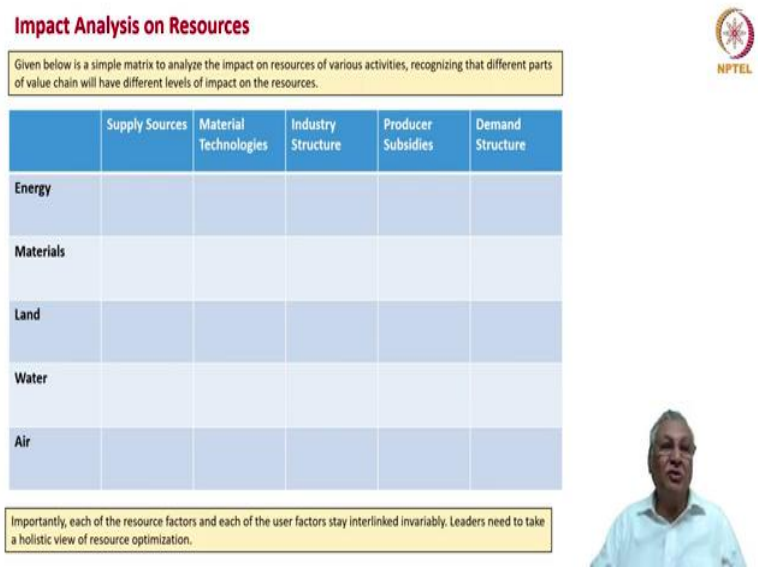

To be able to do that, we need to have some impact analysis done on resources. I have presented here, a typical table which can be used. Let us say we have resources like energy, materials, land, water and air. What do you need to do is that identify the supply sources, identify the material technologies, study the industry which is going to supply those materials, understand whether producers have some subsidies or they need to be incentivized and what is the demand structure for these materials.

Once you are able to list all the resource factors that are required for the industrial transformation or for the existing product, you will find that the supply sources and demand structure are linked through a number of other structural factors relating to technologies, industry structure and also incentives and subsidies. This is an analysis which needs to be done for every new product that would need to be developed.

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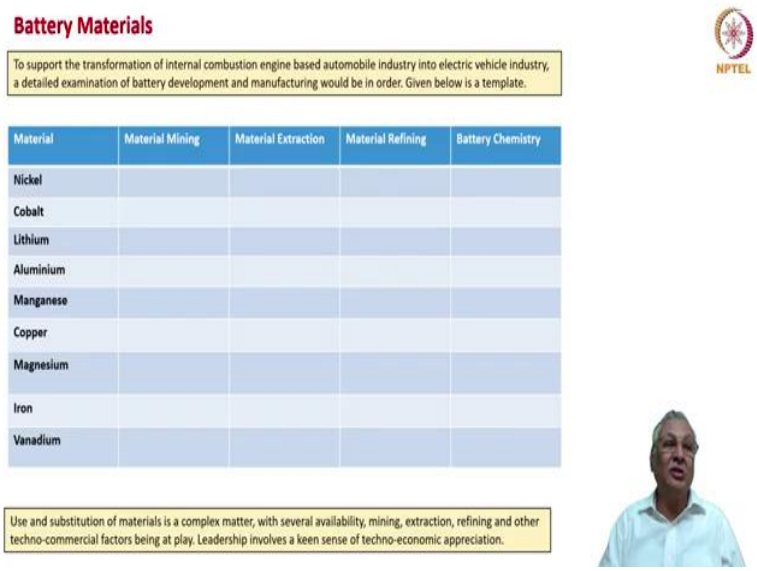

Similarly, you look at the battery materials in a greater detail. We know that a typical electric vehicle battery has got the following materials at the minimum nickel, cobalt, lithium, aluminium, manganese, copper, magnesium, iron and vanadium in different quantities. We need to understand where the material is available and where it can be mined and how it can be mined.

What are the material extraction technologies that are available, who controls those extraction technologies, what are the challenges involved in material refining, because extraction is one part of the job, but really refining the core material from that extracted material is the true challenge, and finally the battery chemistry.

Use and substitution of materials is therefore a very complex matter; with several issues of availability, mining, extraction and refining as also other techno-commercial factors being at play.

As if this complexity is not sufficient, we also have geopolitical considerations, casting their shadow on material availability particularly with reference to high technology products and also rare earth materials and things like that. So we need to have not only a techno-economic appreciation, we also need to have a good geopolitical appreciation.

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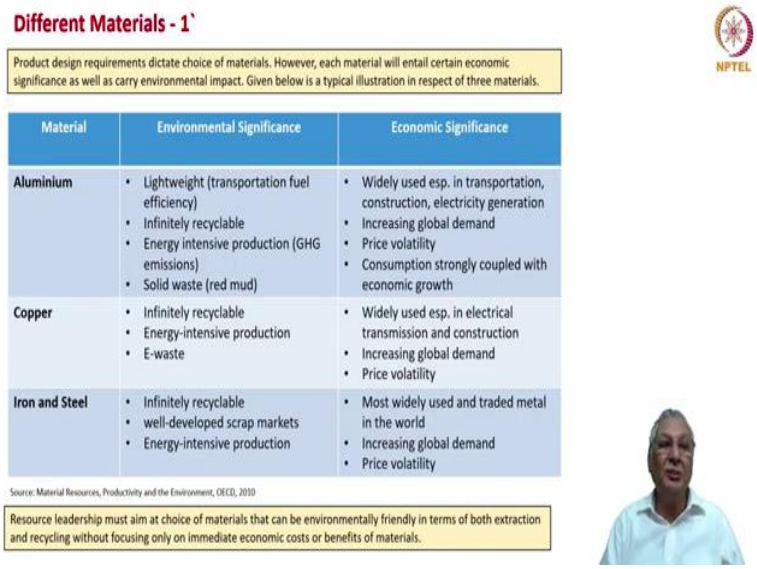

So, let us look at different materials. There are significances of environment and significances of economy that are linked to each type of material. We have to carry out an impact analysis with reference to the environment whenever we think of substituting one material for the other or using one material to a greater degree.

Let us take aluminium, it is definitely lightweight, it has fuel efficiency for transportation, infinitely recyclable unlike iron and steel and certain other metals. It is however, very energy intensive in terms of production and also emits greenhouse gases. It also causes accumulation of red mud the solid waste.

Therefore, there is some positive as well as negative economic significance related to aluminium. It is very widely used especially in transportation, construction and electricity generation. It would see increasing demand globally with the increase in electric vehicles. There would definitely be price volatility. Consumption will be strongly coupled with economic growth. But, the fact that there is a huge environmental significance also has a huge economic significance which needs to be considered.

You look at copper, again another infinitely recyclable material, it also is energy intensive in terms of the production and it creates lot of e-waste. Widely used especially in electrical transmission and construction given the high conductivity. There is also increasing global demand. It is one of the important commodities and is subject to a lot of price volatility.

Iron and steel, again infinitely recyclable, well developed scrap markets, energy intensive production. It is one of the most widely used and traded metal in the world, known for its high levels of strength and known also for the variability in meeting different atmospheric conditions. There is also price volatility.

Now, when you want to shift from one class of material to another class of material, there are technical limits, there are commercial limits, but in some cases they need to be stretched. There are certain things which can be substituted and there are certain metals and materials which cannot be substituted.

So, resource leadership must aim at choice of materials that can be environmental friendly in terms of both extraction and recycling, without focusing only on the immediate economic costs and benefits of materials. You should not look at the price of aluminium or iron and steel and then decide which material to be used.

You similarly cannot look at a battery being available and therefore, look at using batteries for electric vehicle transformation. You need to go back to the starting point of these material value chains and decide and based on analysis, how these have economic and environmental impacts.

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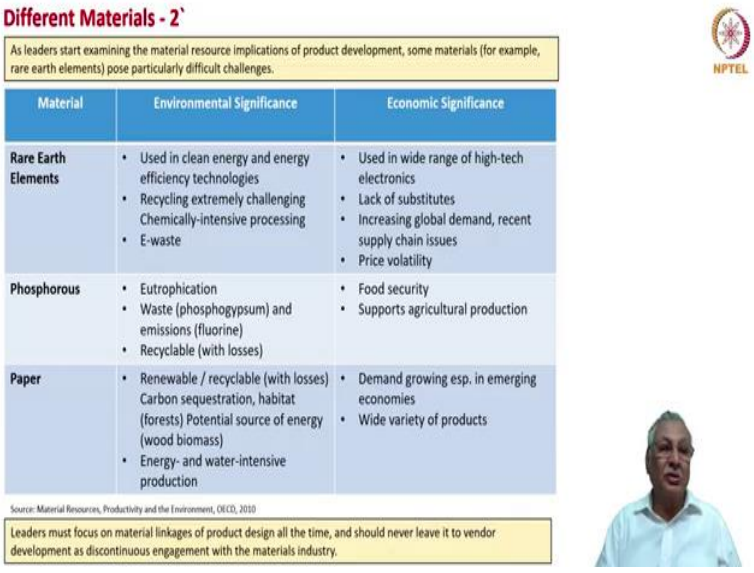

Now, let us look at rare earth materials. These are the rare earth elements which are used in clean energy and energy efficiency technologies. Recycling is extremely challenging.

It is chemically intensive processing and generates lot of e-waste. These are absolutely essential for a wide range of high tech electronics.

They are very costly, prices volatile depending upon the geopolitical conditions and also supply constraints. There are not many substitutes available for the rare earths at this point of time. And the global demand is likely to shoot up as we have more connectivity options coming up.

Let us look at phosphorus, which is an important aspect for agricultural development. It is characterised by eutrophication in terms of environmental significance. The waste that is generated which is phosphogypsum, and the emissions that are also generated; fluorine are not good for the environment. It is of course recyclable, but huge number of steps are involved and losses are also involved in that. Phosphorus is extremely important for ensuring soil fertility and food security, it supports agricultural production.

Now, let us look at paper. We have gone digital substantially, yet paper would remain as one of the most important ingredient for keeping written communication permanent or semi permanent.

The paper is renewable recyclable, again with losses. The significance is that there is carbon sequestration that happens because of the paper usage, habitat is potentially impacted by paper production.

The source of energy, potential source of energy in terms of wood biomass could also be an economically significant factor. And moreover, the production is highly energy and water intensive. You really require large hectares of paper forests to be able to produce paper.

Definitely demand is growing in the emerging markets in spite of the digital revolution and there is a wide variety of products. Paper would still have its own attraction even as we go forward with the digital economy in the future.

Leaders must focus on the material linkages of product design all the time and should never leave it to the vendor development as discontinuous engagement with the material industry could be detrimental to the overall value chain planning.

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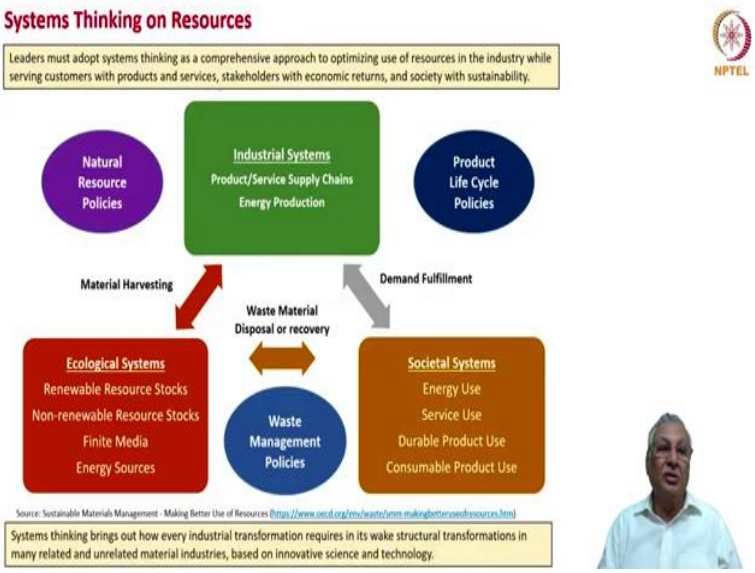

The leader has to look at the resources from a systems point of view. There are three systems which are in operation when we consider resources. The first is the industrial system, which is the product or service supply chain. It is also the energy production system.

A leader is primarily in charge of the end product industrial system or the material industrial system or the metal industrial system. The leaders who are having these verticals with them must also understand the other verticals, without that there cannot be systems thinking as to how the end product can benefit from the materials and vice versa, and how utilities can support both the material and component as well as the end product system.

So, systems thinking at the level of industrial system is extremely important, that determines the natural resource policies and also the product lifecycle policies. However, going forward, we cannot simply look at natural resource policies and product lifecycles based only on the industrial systems.

We got to look at two other systems; these are ecological systems and societal systems or the social systems. Ecological systems have got these implications. What are the renewable resource stocks we have and how they can substitute non-renewable resource stocks; what are the finite media which are available and what are the energy sources which are available.

This ecological system determines the level of material harvesting we can afford to do, keeping in view the sustainability of business as well as the planetary resources. Therefore, the natural resources policies which are done only from an industrial perspective are now modified looking at the material harvesting potential that is possible.

Then we have to look at the social systems as well. The societal system considers use of energy, use of products and services, durability and reliability of products and also consumable product usage, because every product also has got a consumer product that comes along with it. You look at a smart device, you have a case, you have a battery charger, accessories things like that. Similarly, if you look at a printer you require cartridge, you require ink and so on.

Therefore, there are end products there are components there are consumables or supportive elements which make the society utilize the products effectively. So in the industrial system also looks at demand fulfilment.

Looking at demand fulfilment without looking at material harvesting or looking at only material harvesting without looking at demand fulfilment could sub optimise the overall systems thinking in the resource system. And to be able to get a bridge or get a balance between the ecological system, social system and the industrial system, we need waste management policies.

How do I avoid waste as much as possible, and if waste were to be generated, how do I dispose of the waste or how do I recycle the waste. These are the issues which leaders must address very proactively and with great perspicacity. Systems thinking brings out how every industrial transformation requires in its waste structural transformations in many related and apparently unrelated material industries based on innovative science and technology. That is the leadership challenge.

I am talking about resource leadership as one important aspect of leadership again, because readership is far beyond revenue maximisation or profit maximisation. It is about ensuring judicious use of various factor inputs and to be able to do that you as leaders need to appreciate the resource system of the whole world and also the resource cycles that tend to happen in the global industrial system. And to be able to do that the systems thinking is a very important analytical tool with lot of qualitative judgmental factors also impacting the analysis.

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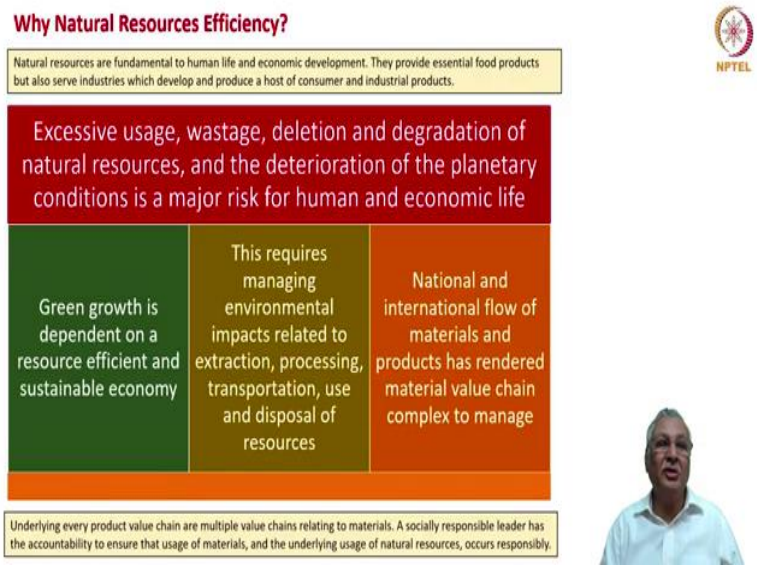

Why should we look at natural resource efficiency? The answer is quite clear, because they are fundamental to human life and economic development and they are not infinite. They provide essential food products on one hand and also serve the industries which develop and produce a whole number of products for us.

Excessive usage, wastage, deletion, degradation of the natural resources and therefore, the consequent deterioration of the planetary conditions is a huge risk for human life and economic life as we go forward. So to be able to have green growth, that is growth which ensures resource conservation is dependent on a resource efficient and sustainable economy.

This requires managing environmental impacts related to the way materials are extracted, refined, processed, transported and used as also disposed of finally. National and international flow of materials and products has rendered, this material value chain very complex to manage. We will try to see in this lecture, how the complexity of national and international material value chains have evolved over the years.

We have to appreciate that underlying every product value chain, we have number of material value chains which are supporting the product value chain. What we see therefore, as the value chain which needs to be optimised by a management team or leadership team is only the tip of the iceberg.

To be able to effectively do a total materials value chain management, you must understand the material value chains which support the product value chain, that is the responsibility of a socially responsible, socially sensitive and environmentally empathetic leader.

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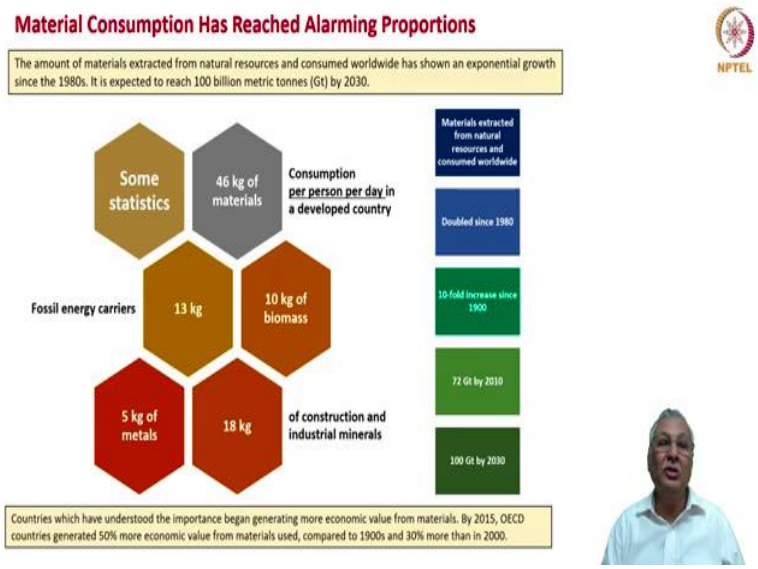

And material consumption truly has reached alarming proposals. I have got certain statistics taken from the OECD and other publications. The amount of materials extracted from natural resources and consumed worldwide has shown an exponential growth since the 1980s. It is expected to reach 100 billion metric tonnes, that is 100 giga tonnes by 2030.

If you see some statistics, every person consumes 46 kg of materials per day in a developed country. Fossil energy carriers are 13 kg, 10 kg of biomass, 5 kg of metals, 18 kg of construction and industrial materials are encompassed in this 46 kg of materials and that leaves aside agricultural and various other inputs which are consumed.

This doubling that has happened since 1980 is of concern, because given the exponential growth in technologies and product introductions, there would be further profligacy in research exploitation. So, how do we cope with that? As I said earlier, materials extracted from natural resource and consumed worldwide have doubled since 1980 and have registered an increase of 10 times since 1900. With a consumption level of 100 giga

tonnes that is expected by 2030, we can only imagine the kind of pressure on the natural resources of this world, this planet.

Countries have understood the importance and therefore are try trying to get more economic value from materials. By 2015, OECD countries generated 50 percent more economic value from the materials used compared to 1900, 30 percent more than in 2000. Organizations such as OECD are drawing the attention of the governments as well as industries to the need to ensure greater economic value from the materials that are being used presently and in future.

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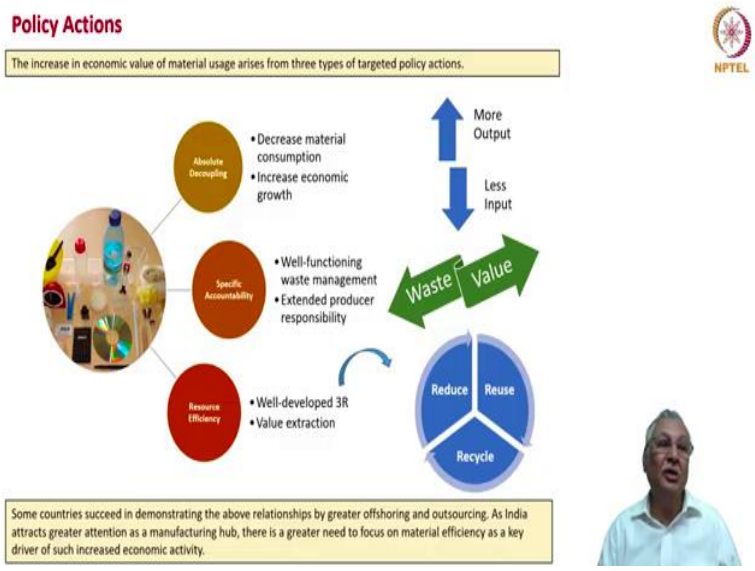

The increase in economic value of material uses arises from three types of targeted policy actions. This is not merely a governmental action industries and industry leaders can also do. One; absolute decoupling, that is there cannot be a one to one relationship between product usage and material usage, we should decrease the material consumption and increase economic growth.

The introduction of miniaturisation, the introduction of smaller form factor have been tremendous inputs for decreasing material consumption while enhancing the economic value of a particular product. That said, we still have more and more products coming out into the marketplace with the higher form factors and also with higher material consumption.

That is an inescapable law of marketing, try to segment the market consistently and continuously into smaller segments and trying to derive the maximum value that is the business consideration. But from a socially relevant leadership, we need to look at absolute decoupling as well. Whatever we do in whatever segment, we should try to decrease the material consumption and increase the economic value.

Second, specific accountability we should be accountable to minimise waste from any industrial process or transportation process, and we should have extended producer responsibility. Which means; that if somebody produces smartphones that producers should also be responsible to take the smartphones back when they supply newer smartphones and recycle and recover as much as possible from the discarded smartphones.

We also should have the third plank of resource efficiency; the 3R formula, which is reduce, reuse, recycle and that would ensure that the value extraction from the basic first kg of material that has been developed or extracted or refined is stretched to the maximum.

While the nominal productivity equation of more output and less input is always relevant, we should also see how waste can be minimised continuously and value increased continuously through every product action and every strategic management action related to product development or service delivery. And those countries which succeed in demonstrating the above relationships do that by greater offshoring and outsourcing.

As India attracts greater attention as a manufacturing hub, there is a great need for us to demonstrate to the world that we are not only capable of providing products and components, so we are also capable of producing them and supplying them in an economically efficient and environmentally empathetic manner. That will position India very high in the world committee.

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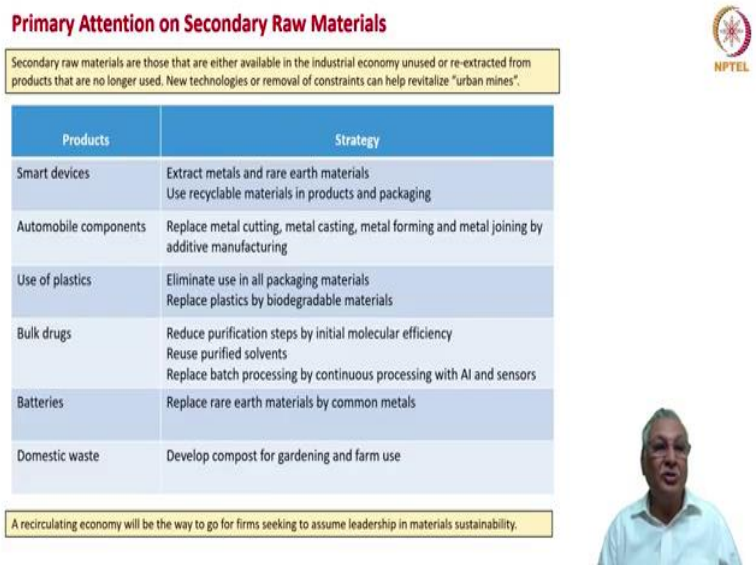

We also should have primary attention on secondary raw materials. When I say secondary raw materials those are that which are either available in the industrial economy unused or re-extracted from products that are no longer used. New technologies or removal of constraints can help revitalise the urban minds.

Let us take the example of smart devices. We need to extract much higher level of metals and rare earth materials from the smartphones. We need to use recyclable materials in products and packaging. We also are seeing elimination of unnecessary aids and accompaniments in these smart device packaging.

Extra plastics are eliminated, there is no need for an integrated charger. We are trying to use the operating instructions through the digital means rather than have huge operator manuals or user manuals. So, steps are being taken that; however, has to focus on the product itself.

Second, automobile components. We need to replace all processes which involve loss of metal or loss of materials; such as metal cutting, metal casting, metal forming, and metal joining by additive manufacturing, wherein powder is used through some bonding agent to make the end product without loss of material.

Use of plastics; eliminate use in all packaging materials, replace plastics by biodegradable materials. When you look at bulk drugs that is the active pharmaceutical

ingredients in the pharmaceutical industry, we should reduce the purification steps that are required by initial molecular efficiency.

The reason why lots of steps are involved from reactor to reactor in processing the material and also adding several solvents is because the basic molecular intermediate or the raw material from which we start the process of developing the final bulk drug is not very efficient.

If you are able to get the initial molecular entity highly efficient and as close to the final molecular entity as possible, then we will be able to reduce the purification steps. The second step is to reuse the purified solvents and the third one is to replace batch processing which involves a lot of transportation and conversion of material from one reactor to other reactor.

We need to have continuous in situ processing fully with artificial intelligence and sensors, so that the temperature and other operating conditions are controlled in a very fine manner. When you look at batteries, we should replace rare earth materials by more commonly available metals and materials.

The domestic waste, we should develop compost for gardening and farm use from every household which generates domestic waste. We should have technologies which will ensure that each house is self sufficient in its waste management. A recirculating economy will be the way to go for firms seeking to assume leadership in material sustainability.

When we look at these kinds of opportunities, these are actually new industries and new business opportunities that could spell enormous business opportunities for socially responsible, socially responsive and environmentally empathetic entrepreneurs. And big companies also can incubate entrepreneurial ventures which will help in these areas. And these are only sprinkling of what is possible in terms of resource conservation.

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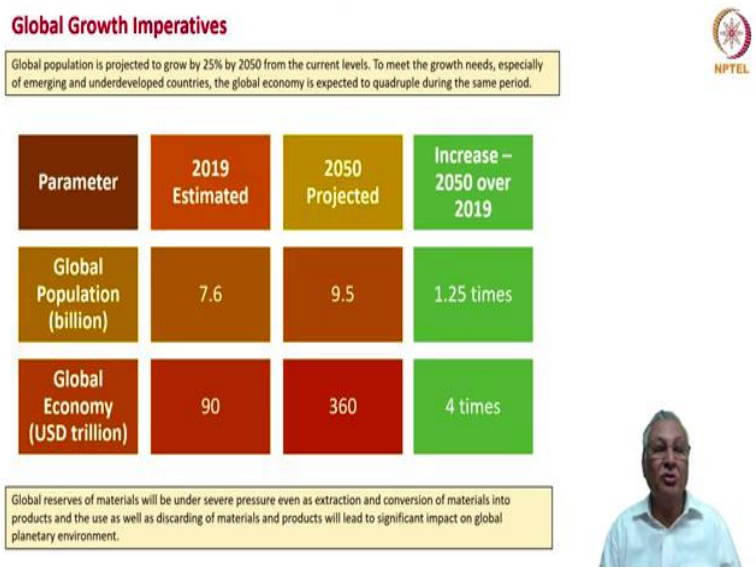

So, what are the global growth imperatives? Global population is projected to increase by 25 percent by the year 2050 from the current levels. To meet the growth needs especially of emerging and underdeveloped countries the global economies is required to quadruple during the same period.

That is because, most of the emerging economies and near developed economies have got a long way to go to elevate the standard of living for it is a huge population. So, when population goes up by only 1.25 times, the economy itself which is USD 90 trillion dollar at this stage has to go up 4 times to 360 trillion dollar. What would that mean? More industrial production, more transportation and more utilization and exploitation of materials.

Obviously, the global reserves of various materials will be under severe pressure from extraction and conversion of materials into end products. Use and discarding of materials and products will lead to significant impact on global planetary environment. If we look at even today's crisis of COVID-19 and the huge demand that has generated for personal protective equipment.

And the additional demands for discarding them and eliminating them in an environmentally and medically safe manner. You can see that a whole new industrial substratum has emerged to be able to cope with this COVID-19 pandemic purely from a

supportive domain. Therefore, the global growth imperatives are far larger than the population increase trends that are likely.

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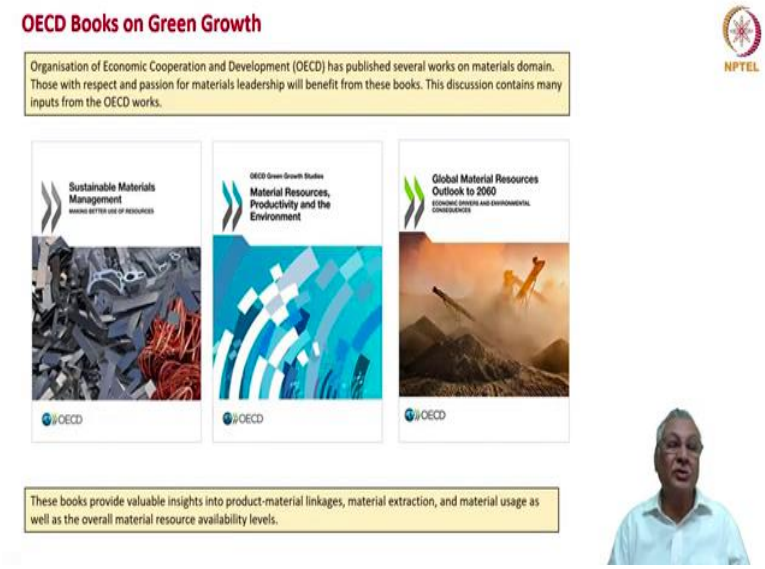

To be able to understand this domain which is very complex, we need to consult several books. For those who are further interested in the sustainable materials management approach and resource conservation, I would recommend three books which are published by OECD; one is sustainable materials management; the other is material resources productivity and environment and global material resources outlook to 2060.

While I have tried to present some of these frameworks here, obviously time and space are a limitation. You can consult these books and find out several frameworks that will expand our thinking with respect to sustainable use of materials. Very valuable inputs are provided in terms of product material linkages, material extraction, material usage and material recycling technologies and methodologies that could be utilized by the industries.

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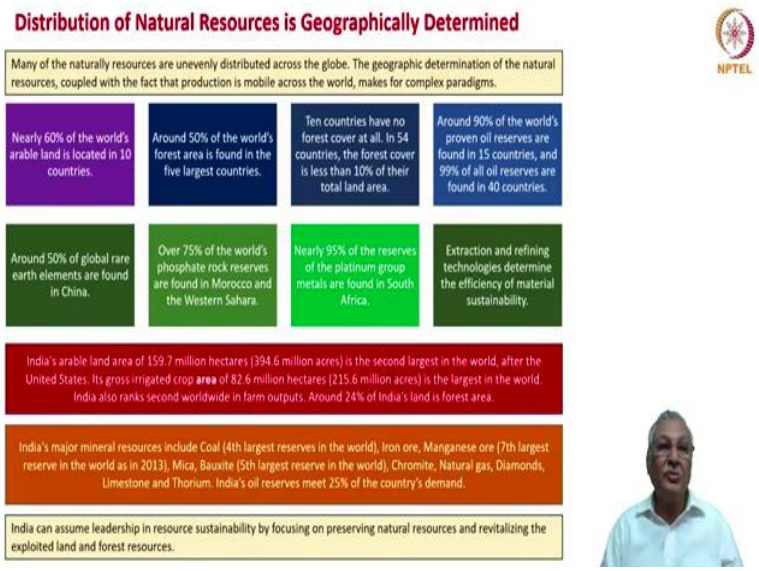

We should also recognise that distribution of natural resources is geographically determined. We cannot alter easily the availability of natural resources. Some statistics; nearly 60 percent of the worlds arable land is located in just 10 countries; arable means fit for agriculture. Around 50 percent of the world's forest area is found in the 5 largest countries and 10 countries have no forest cover at all.

In 54 countries the forest cover is less than 10 percent of the total land area. Around 90 percent of the worlds proven oil reserves are found in 15 countries and 99 percent of all oil reserves are found in 40 countries, whereas, we have got over 130 countries and territories which are in existence on this planet.

You can see the skew in terms of the arability of land and the availability of natural resources, which means a much larger proportion of the world is dependent on resource rich regions of the world. That is one skew that is geographically determined, we cannot do much about it.

Similarly, if you delve deeper, around 50 percent of global rare earth elements are found in China, over 75 percent of the worlds phosphate rock reserves are found in Morocco and the Western Sahara. Nearly 95 percent of the reserves of the platinum group metals are found in South Africa. Extraction and refining technologies determine the efficiency of material sustainability and these are available in a developed state with a few countries only.

If you look at India, our arable land area of 159.7 million hectares or 394.6 million acres is surely the second largest in the world after United States. It is our grass irrigated crop area of 82.6 million hectares which is to 15.6 million acres is the largest in the world. We are the second largest in terms of the arable land area and the largest in terms of the irrigated crop area.

We are also ranking second worldwide in terms of farm outputs, around 24 percent of India's land is forest area. Who can say that India is not a blessed country, India is certainly a blessed country. But how do we utilise these natural resources? How do we preserve this strength of the natural resource and even reinforce it as we go forward in trying to meet the expanding lifestyle needs, expanding population needs in a much more balanced manner, in a much more judicious manner.

Our major mineral resource include coal. We have the 4th largest level of reserves in the world. Iron ore and manganese ore 7th largest reserve in the world as of 2013. Mica and Bauxite 5th largest reserve in the world, Chromite, Natural gas, Diamonds, Limestone and Thorium. Our oil reserves are capable of meeting 25 percent of the country's demand.

Therefore, India can certainly assume leadership in resource sustainability by focusing on preserving natural resources and revitalising the exploited land and forest resource. So, this is not something which we can ignore as a leadership concern. It is very much a leadership imperative to utilize what god has given to our country.

To India as a nation and see that the natural resources are protected, preserved, further developed along with development of industrial products, along with development of a manufacturing capability not only for India, but for the entire world. So, India has great economic opportunity through globalisation. India also has got a great national and social responsibility to utilize the resources in a very perspicacious manner in meeting the requirements of the industrial production.

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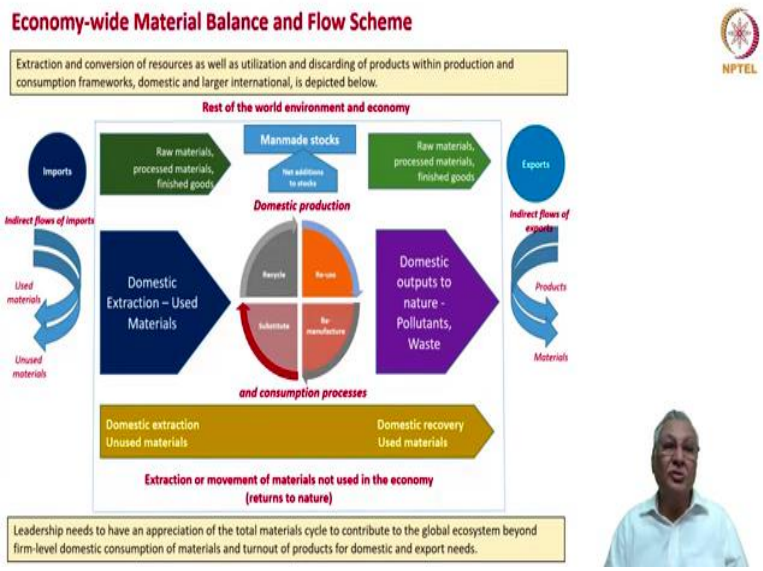

So, when you look at the economy wide material balance and flow scheme, OECD proposes this framework. You have imports of raw materials, processed materials and finished goods. You also have exports of raw materials, processed materials and finished goods. In between you have net addition to the stocks, in terms of manmade stocks, that is the domestic production.

We have domestically extracted materials which are used and we also provide domestic output to the nature in terms of pollutants and waste. We have indirect flows of imports in terms of used materials and unused materials whereas, we have indirect flows of exports in terms of products and materials.

All this is bridged, this entire domestic production and consumption process which is partially dependent on imports and partially on domestic supply base and is used in terms of both domestic consumption and export consumption is marked by domestic consumption through domestic extraction of unused materials and domestic recovery of used materials.

We have to extract or move materials which are not used in the economy and return the materials to the nature. Leaders need to understand this material balance and flow that dictates resource utilization in any industry or in the economy itself. We need to understand as leaders, the total material cycle to be able to contribute not merely to our

forms ecosystem but to the entire global ecosystem beyond the form level consumption and utilisation factors.

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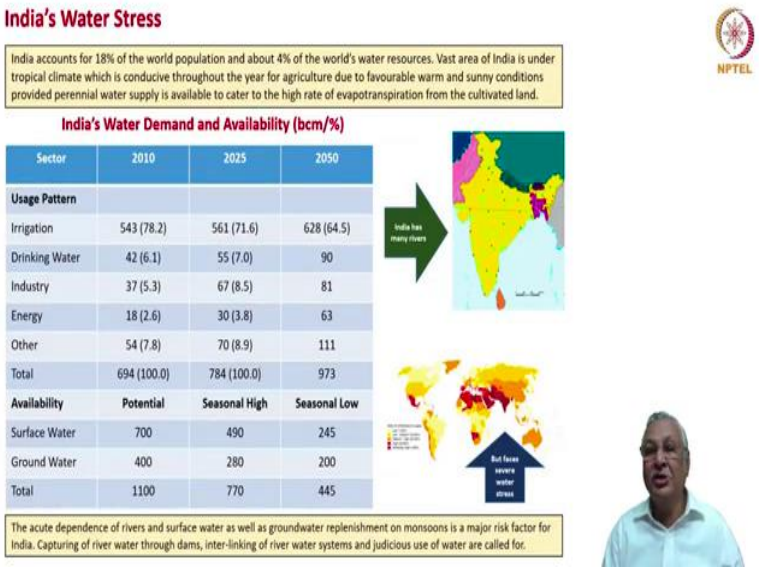

India is a country which has got significant water stress. We have 18 percent of population residing in our country and 4 percent of the worlds water resources only are available within the nation. Vast area of India is under tropical climate, which is really conducive for all round year agriculture. Due to the favourable warm and sunny conditions; however, we are not able to cultivate the land perennially because of the volatility in the availability of water and the evapotranspiration from the cultivated land.

So if you look at the India's water demand and availability profile in terms of billion cubic metre and as a percentage, you will find that the usage pattern substantially goes to irrigation and drinking water. Industry consumes fair bit, energy consumes also fair bit and others both industry and energy put together.

So how would you ensure that we have the appropriate surface water, groundwater availability to be able to meet? So the potential, the seasonal high, the seasonal low determine whether we are going to be water stressed. Statistics indicate that we are likely to be water stressed because even at seasonal high our total requirement by 2025 will not be fulfilled. And if we have to think of seasonal low we are likely to end up with severe water shortage and water stress by 2050.

So consumption of water, preservation of water, recycling of water are extremely important aspects for leadership. We have many rivers, but we face severe water stress. How do we overcome that? Ensure that rivers are interlinked, it is a huge technological challenge. Construction firms have got a great role to play. When we have Bharat Mala, Sagar Mala, we also need to have a river Mala which connects all the rivers of the country so that we meet the ups and downs through a kind of networked supply of water.

So, similarly groundwater replenishment with or without monsoons is a major issue for us. How do we manage groundwater replenishment? Alike to that is, how we use water very judiciously for our irrigation purposes, our hydroelectric purposes.

We need to capture water through more dams we have to interlink river water systems and so on. Many of these things are not only technological challenges, but also managerial challenges leadership challenges. We need to look at leadership at particularly administrative leadership which handles this issue.

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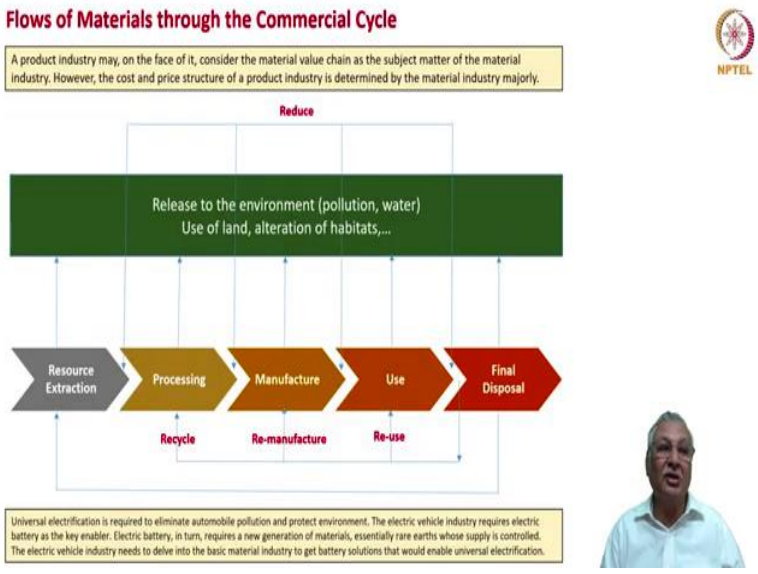

So in a commercial cycle, which is an industry cycle the issues are little different. We extract the resource, we process the resource, we manufacture the product, we use the product and finally, we dispose of the product. Through this process, we release to the environment at all levels, certain pollutants and also wastewater. We use our land, we alter habitats and the goal should be to reduce all of these releases to the environment, reuse all of these utilizations of the natural resources.

And when we go through this manufacturing flow cycle, we need to ensure that we use recycled materials in processing, we re-manufacture wherever it is possible and wherever required we reuse the product rather than condemn the product. It is encouraging that we talk about refurbished cars, we talk about made new products that are being sold by dealer networks or by special car manufacturers verticals or by E-commerce platforms. It is a good trend.

However, how do we ensure that certain other factors which are come along with, let us say e-commerce, excessive packaging, everything is packed in unit numbers leading to severe pollution in terms of cardboard usage and disposal. How do we take that? That is where producer responsibility, the distributor responsibility, the marketer responsibility come into being.

Similarly, when we look at universal electrification, we got to think of new generation of materials which are not pollutant and we should get the best of material industry support the electrification drive early on, rather than look at that as the next incremental phase of electrification. We should look at universal electrification with an optimal electrification approach. And for each industry vertical, we have got similar such examples of requirements.

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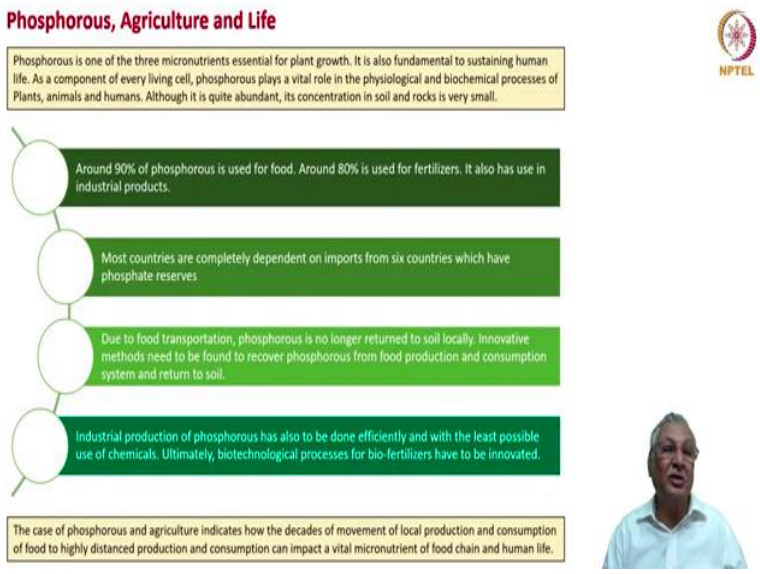

We shall look at, let us say agriculture. Agriculture and life are very closely involved. Phosphorus is one of the key micronutrients, in fact, one of the three which are required

on an essential basis for plant growth. It is also fundamental to sustaining human life. As a component of every living cell phosphorus plays a vital role in physiological and biochemical process of plants animals and humans.

Although it is quite abundant, its concentration soil and rocks is very small. So it cannot be extracted easily. Around 90 percent of phosphorus is used for food, around 80 percent is used for, you would have heard of urea based fertilisers phosphorus based fertilisers. So, 80 percent of phosphorus is used for fertilisers because it is believed that it would enhance the fertility of the soil. It also has got certain use in industrial products.

Most countries are completely dependent on imports from 6 countries which have phosphate reserves, we talked about that in an earlier slide. However, due to food transportation, phosphorus is no longer recycled or given back to the nature in the same place where it is deployed, where it is harvested as crop.

Therefore, the phosphorus cycle itself is disturbed and the level of phosphorus that is available is depleted. So, we need to have innovative methods, so that, we can recover phosphorus from food production and consumption system and return to soil in a judicious manner. We also have to do the industrial production of phosphorus very efficiently with the least possible use of chemicals.

Ultimately biotechnological process for bio fertilisers have to be innovated so that the use of phosphorus for fertilisers is minimised. The case of phosphorus and agriculture indicates to us how decades of movement of local production and consumption of food to highly distanced production consumption centres has impacted a vital micronutrient of food chain and human life; which is phosphorus.

So, such things happened without even our acknowledging, such happenings as we look at our responsibilities. So, leaders who deal with consumer goods, with food processing activities need to recognise these kinds of environmentally epithetical issues.

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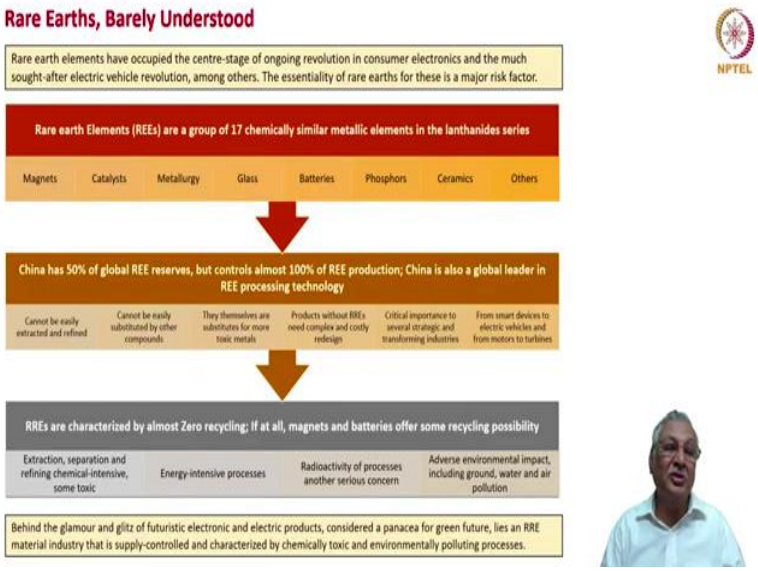

As far as rare earths are concerned, they are barely understood. Nobody really thinks of a rare earth material which is actually powering the smartphone. We are all excited by the glitz and glass of the smartphone and the processing speed and so on, but what makes the smartphone tick? It is the rare element these are a group of 17 chemically similar metallic elements in the lanthanide series. They help us develop magnets, catalysts, metallurgical items, glass, batteries, phosphorus, ceramics and whole lot of specialty items.

China has 50 percent of global REE reserves, but controls almost 100 percent of REE production. China is also a global leader in REE processing technology. The issue with rare earths is that the rare earths cannot be easily extracted and refined. They cannot be easily substituted by other compounds, because they themselves are substitutes for more toxic metals.

Products with the rare earths need complex and costly redesign if you want to eliminate them. And they are of critical importance to several strategic and transformational industries from smart devices to electric vehicles and from motors to turbines. So they are a part of our life.

So, how do you discover more rare earths, how do you have more distributed ownership of the rare earths and how do we acquire and enhance our rare earth processing and extracting and refining capabilities? These are the issues for leaders. These are characters

by almost zero recycling as of now. If at all, magnets and batteries offer some recycling possibility. So we have to consider these technological aspects as well.

If you want to extract, separate and refine chemical intensive rare earths some are toxic. These are all energy intensive process. There is also radioactivity which arises from the recycling and recovery process. And there is also an adverse environmental impact because whenever you do recover a product what you get as the final residue is highly toxic. It will pollute groundwater and air pollution to an even greater degree.

Therefore, as I said behind the glamour and glitz of futuristic electronic and electric products which are considered a panacea for a green future through work from home or communicating through laptops, smartphones and computers, there lies a huge RRE challenge.

A RRE material industry which is not very well understood, which is controlled by geopolitical considerations and technological monopolies and also challenged by chemically toxic and environmentally polluting process. We need to address this material sustainability at the basic foundational level so that the transformation towards the digitally networked digitally connected economy can take place without an underlying environmental issue which is not disclosed or discovered at this current stage.

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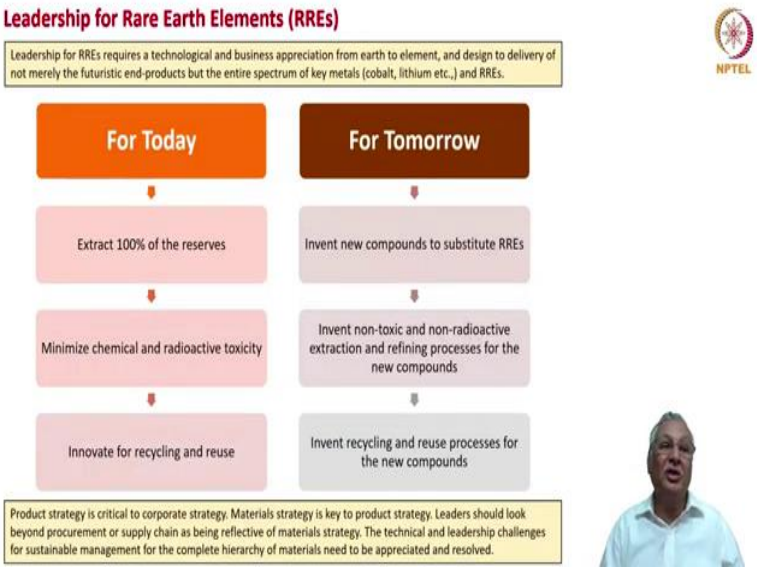

So, what are the leadership challenges for rare earth elements? For today, we should try to extract 100 percent of the reserves. As I said, 50 percent only is extracted and owned by China. Still 50 percent is left. We have to minimise chemical and radioactive toxicity which is involved in such process. We have to innovate for recycling and reuse. But for tomorrow, we have to invent new components which are less toxic and more easily available to substitute RREs.

We need to invent non toxic and non radioactive extraction refining process for the new compounds, and also to the extent these rare earths are still used for them as well. We have to invent recycling and reuse processes for the new compounds. Product strategy is critical for corporate strategy, but for product strategy to be successful we need a material strategy. That should be the key. And for material strategy to be successful, we need a sustainable materials strategy.

We should look beyond product procurement. We should look beyond materials procurement. We should look beyond supply chain management. We should not think that they are the end all of material strategy. The real technical and leadership challenges for sustainable management of resources is really understood when we appreciate the total hierarchy of materials that need to be utilised for developing a product.

So, the entire bill of materials down to the last usable material as the foundation, that needs to be understood for us to ensure sustainable resource management in the industry and in the economy.

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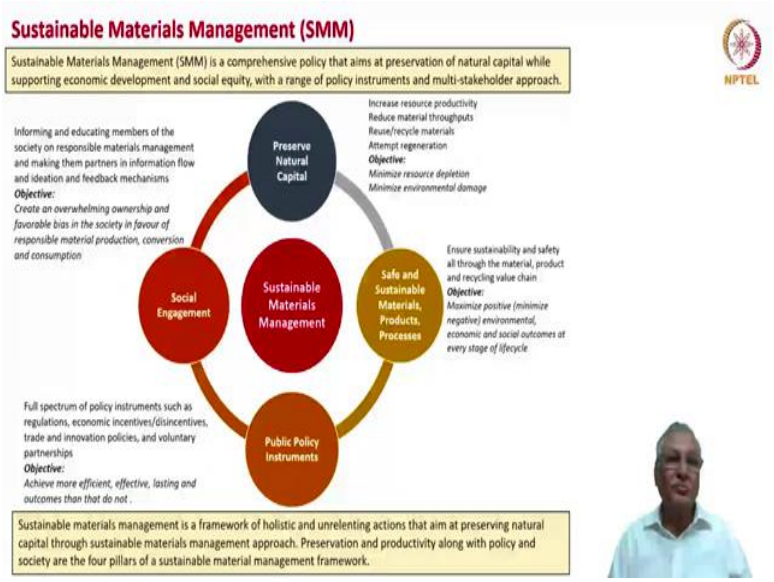

So, what are the four pillars of sustainable materials management? One; preserve natural capital which has got several methodologies, increases resource productivity, reduce material throughputs, reuse recycle materials, attempt regeneration. What is the objective? Minimise resource depletion minimise environmental damage.

The second pillar; safe and sustainable materials, products and process. Whatever materials we use and the processes we use for extracting them must be safe, sustainable and that we can use through having appropriate recycling value chain. We have to maximise positive and minimise negative environmental economic and social outcomes at every stage of lifecycle.

We should have as the third pillar public policy instruments with the objective of more efficient effective and lasting outcomes than that do not, for that we need a full spectrum of policy instruments regulations, economic incentives and disincentives, trade and innovation policies, voluntary partnerships, joint ventures, co-ownership of material sources, balancing of geopolitical considerations and so on.

And the fourth pillar is social engagement. Informing and educating members of society on responsible materials management and making them partners in information flow and ideation and feedback mechanism. If you could accept a smartphone without any packaging, let us get to such a situation. If you want to have packaging, which does not have the plastic embellishment, but is simple cardboard packaging let us go to that stage.

So, we need to educate our own society in terms of responsible materials management that has the objective of creating an overwhelming ownership and favourable bias in the society in favour of responsible material production, conversion and consumption.

If we are able to have these four pillars driving our industrial system and the economic system, sustainable materials management will be part of the national DNA and that will ensure a holistic and unrelenting action plan that will preserve the natural capital for posterity. So, preservation and productivity are important and they should be given highest priority by leaders.

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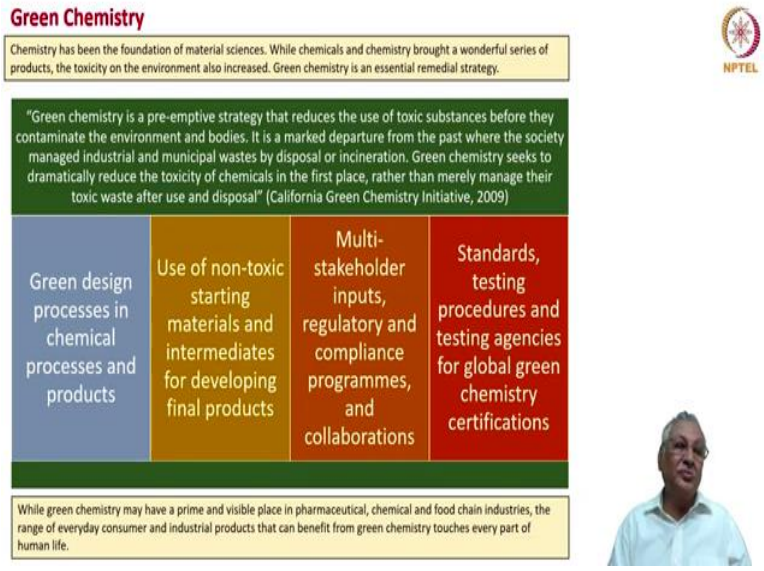

Another aspect is green chemistry. That is, the chemistry has been the foundation of material sciences, while chemicals and chemistry brought wonderful transformation in products and particularly in pharmaceutical industry the toxicity on the environment has also increased.

Green chemistry is an essential remedy and strategy. Green chemistry is defined this way by California green chemistry initiative 2009, I will read it out for you. Green chemistry is a pre-emptive strategy that reduces the use of toxic substances before they contaminate the environment and bodies. It is a marked departure from the past where the society managed industrial and municipal wastes by disposal or incineration.

Green chemistry seeks to dramatically reduce the toxicity of chemicals in the first place, rather than merely manage their toxic waste after use and disposal. It is a proactive, preventive, chemistry driven methodology to ensure that there is no environmental pollution.

How is this displayed? Green design process in chemicals and other products, use of non toxic starting materials, intermediates and other materials for developing final products. Multi stakeholder inputs, regulatory and compliance programmes and collaborations and high levels of standards, testing procedures and testing agencies for global green chemistry certifications.

It has a prime and visible place in pharmaceutical, chemical and food chain industries, but the range of industrial and consumer products that could benefit from green chemistry are also many. The potential of green chemistry is such, industries is not yet fully recognised and research could focus on that as well.

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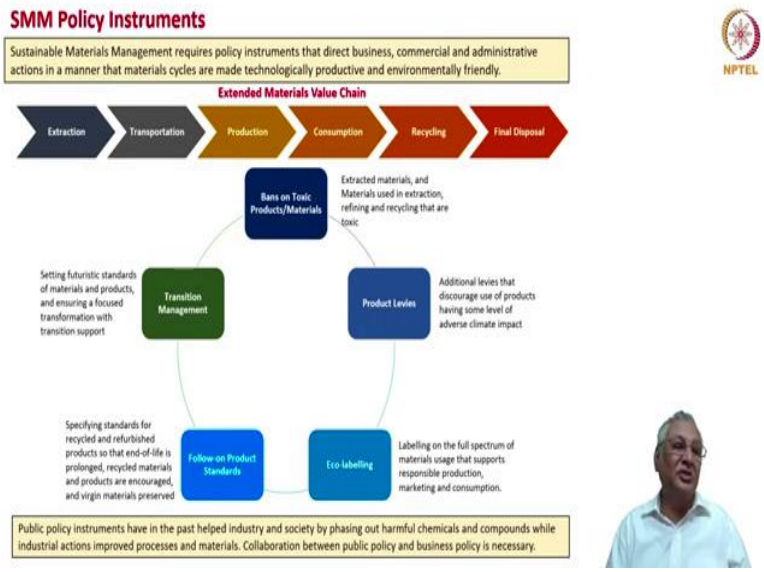

So, the materials value chain, as I said is pretty long value chain much beyond what we can see within the confines of the forms which we manage or we are parts of, from extraction, transportation, production, consumption and recycling to final disposal we have the extended materials value chain. And remember, each value chain is supported by other material value chains. And to be able to do that in a sustainable manner we need to have incentives as well as disincentives.

We need to have bans on toxic products and materials. PPA was banned in food grade materials. As technology improves, as our understanding of the safety or unsafety parameters of products improves, more toxic materials will be discovered and we need to avoid the use of such products and materials.

We need to have additional product levies to discourage use of products which have a level of adverse climate impact. We should have eco-labelling, so that we are encouraged to buy and use products which are environmentally friendly and also support firms which are environmentally friendly.

Having eco-labelling for firms' products should be seen as one of the considerations for ESG investment. We need to have follow on products starting. We do have standards for products which is fine, and they could also be reinforced and upgraded from time to time.

But what is important is that, we should have standards for recycled and refurbished products also, so that the end of life is prolonged as much as possible. We should have standards for recycling materials so that recycling and reuse of materials can be encouraged and we should also have holistic appreciation of this first use and secondary use mind-set, so that the virgin materials are preserved as much as possible.

It is probably very sinful to dispose of a smartphone within 6 months of its use, because the basic life of those precious materials which are there in the smartphone could last and last for several years.

So we need to find out which is the weakest link in the smartphone and ensure that its life is prolonged as much as possible and standards are important for that. Then, we should also have transition management to a sustainable materials management paradigm which has futuristic standards for materials and products, so that the transformation occurs with appropriate transition support.

Public policy instruments have helped a number of industries, navigate themselves through this transformation process, phasing out of harmful chemicals reducing the levels of pollution on road and also use of appropriate non toxic compounds in chemical and fertiliser industries are just some examples of how public policy instruments, those seeming to be painful in the beginning have helped industries come out with better

products and socially responsive and relevant products. We need to have such collaboration between public policy and business policy on a continuing basis.

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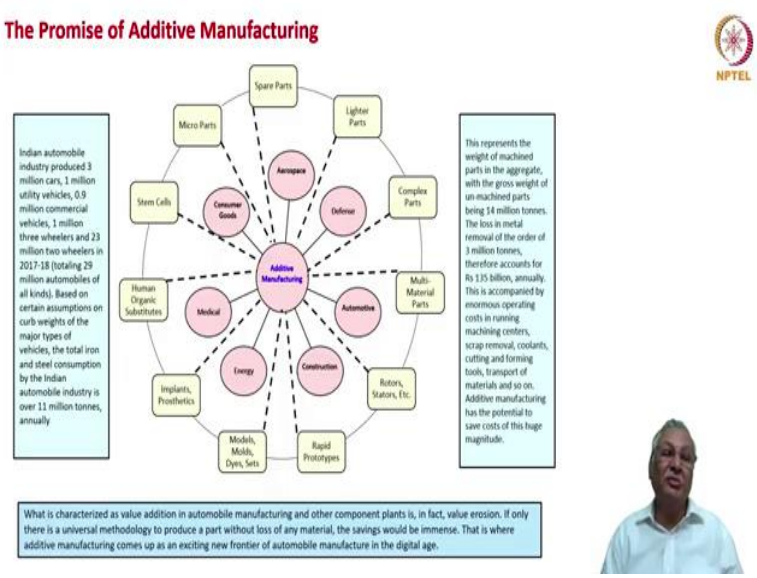

I talked about various metal manufacturing process like machining, forming, forging, casting and welding. And I pointed out to the huge loss of materials that could happen in a qualitative fashion. But let us look at one example; Indian automobile industry produced in total 29 million automobiles of different kinds in 2017-18.

Based on certain assumptions on curb weights of major types of vehicles, the total iron and steel consumption by the Indian automobile industries over 11 million tonnes annually. This represents the weight of machine parts in the aggregate with the gross weight of un machined parts could be several times, several million tonnes more. And one conservative estimate by me is that it is the order of 3 million tonnes extra.

So, if you are able to save these 3 million tonnes of metal removal that happens during the manufacturing process, we would be able to save 135 billion rupees annually. We would also save the enormous costs which are there in operating those machine tools which remove the materials, which cast the molten metal, which join two metals, which form the metal parts all that is removed. So, the saving would actually be much higher than that. And also the transportation and various other activities.

So additive manufacturing also called 3D printing is an important improvement that could transform the manufacturing process. It could be applicable not merely for industrial prototyping as being attempted now, but even for mass manufacturing across a range of industries consumer goods, aerospace defence, automotive, construction, energy, and medical.

Wherever you have an overall envelop of a part or the material which is kind of cut to shape or machined to size or developed to size, we can apply additive manufacturing so that you get what you want without any loss of material directly from the computer design.

So we can have micro parts, spare parts, lighter parts, complex parts, multi material parts, rotors, stators, rapid prototypes, moulds, models, dyes, sets, implants, human organic substitutes and even stem cells developed through additive manufacturing. So, we should have a mindset change.

What you think actually as value addition in an automobile factory or a manufacturing factory is actually value erosion, because you are taking 14 million tonnes of material, removing 3 to 4 million tonnes of material and then pricing it more, because of the conversion costs that are involved in the factory and we are saying it is value added that is how the global industries ran till now.

But the entire concept is turned the other way when we look at additive manufacturing. We just take what is required, produce a part and then supply it. That is the kind of revolutionary thinking you must have and that is the kind of revolutionary execution we should have in terms of no loss manufacturing, so that sustained materials management is part of the day to day industrial life.

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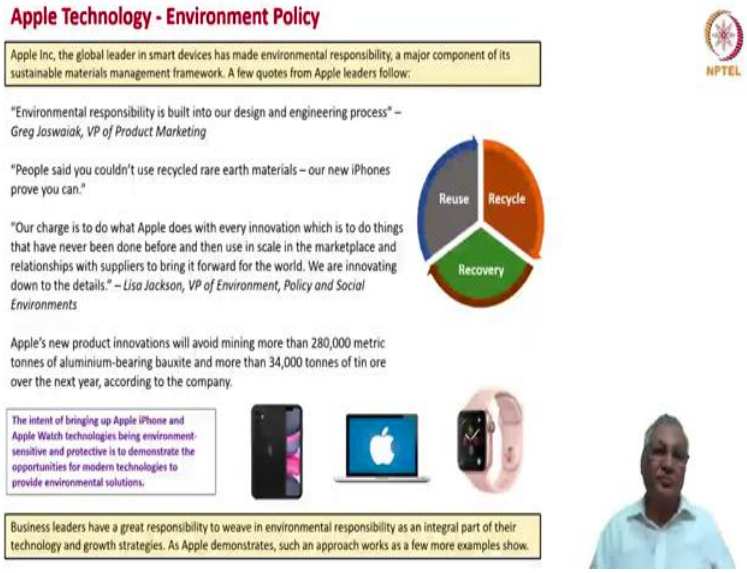

Companies which are responsible, which are market leaders are trying to implement these policies to some extent or the other. Apple's sustainability report talks about its philosophy of reuse, recycle and recovery. "Environmental responsibility is built into our design and engineering process" says the VP of product marketing. "People said you could not use recycled rare earth materials - our new iPhones prove you can".

VP of environment policy and social environments talks about their responsibility. Our charge, means our responsibility is to do what Apple does with every innovation which is to do things that have never been done before and then use them in scale in the marketplace and use them in the relationships with suppliers to bring it forward for the world. We are innovating down to the details.

According to the sustainability report, Apple's new product innovations will avoid mining of more than 280,000 metric tonnes of aluminium bearing bauxite, more than 34000 tonnes of tin ore over the next year according to the company. The point for bringing up Apple iPhones and Apple watch technologies, being environment sensitive and protective is to demonstrate the opportunity for modern technologies to provide also environmental solutions.

And the business leaders, who have the necessary capability and the power, they should do everything possible to weave in environmental responsibility as an integral part of their product strategies, technology strategies, growth strategies and corporate strategies.

And as Apple demonstrate such an approach works, as a few more examples also will show.

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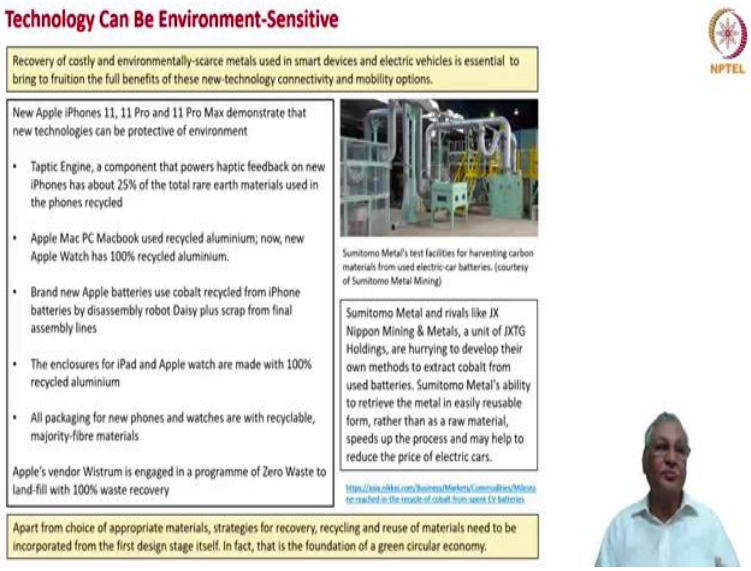

The taptic engine in the new Apple phones which is the component that powers haptic feedback on the phones, as about 25 percent of total rare earth materials used in the phones being recycled. Apple PC MacBook use recycled aluminium hitherto, now new Apple watch also has 100 percent recycled aluminium.

Brand new Apple batteries use cobalt recycled from iPhone batteries by disassembly robot daisy plus scrap from final assembly lines. The enclosures for iPad and Apple watch are made with 100 percent recycled aluminium all packaging for new phones and watches are with recyclable majority fibre materials.

Apple's vendor Wistrum is engaged in a programme of zero waste to landfill with 100 percent waste recovery target. These are again from Apple's sustainability report. So recovery of costly and environmentally scarce metals which are used in smart devices and electric vehicles is one huge step necessary to bring to fruition the full benefits of this new technology connectivity and mobility options.

We also have several other industrial examples. Sumitomo test facilities for harvesting carbon materials from used electric car batteries which is illustrated here, courtesy Sumitomo Metal Mining, this is very reflective. What was thought to be impossible is

being made possible by technological developments. They are hurrying to develop their own methods to extract cobalt from used batteries, not merely Sumitomo metal, but also their rivals.

The ability to retrieve the metal in easily reusable form rather than as the raw material speeds of the process and may help to reduce the price of electric cars as well. So, apart from choice of appropriate materials, we also need to deploy technology to ensure that recovery, recycling and reuse is made possible to the highest level and it should be incorporated from the first design stage itself. That is the foundation of a green circular economy.

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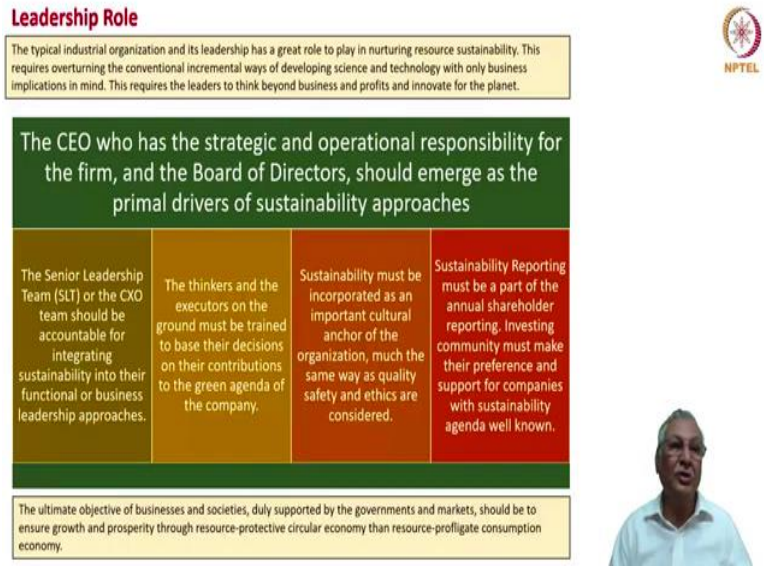

What is the leadership role in this? The typical industrial organization and its leadership has a great role to play in ensuring the physical and financial numbers without doubt, ensuring a sustainable growth rate for the business these are all given. But, there is also a great responsibility which is not easily appreciated within the organization or outside the organization of nurturing resource sustainability.

This requires overturning the conventional incremental ways of developing science and technology with only business implications in mind. This requires the leaders to think beyond business and profits and innovate for the planet. If you save a few dollars or a few 100 rupees for the consumer, with a better product which has the long lasting

premium effect and which has a long lasting durability and reliability, the money saved could be used for another important product.

It is not necessary to look at introducing products every 6 months, so that the volume levels keep going up. That is the conventional wisdom. The new wisdom requires bringing in resource sustainability in this process of business development and business growth.

The CEO who has the strategic and operational responsibility for the firm, as also the board of directors should emerge as the primary drivers of sustainability approaches. The senior leadership team of the company, that is the CXO team should be made accountable for integrating sustainability into their functional or business leadership approaches.

The thinkers and executors on the ground must be trained to base their decisions on their contributions to the green agenda of the company. Sustainability must be incorporated as an important cultural anchor of the organization, much the same way as quality, safety and ethics and even occupational health are considered.

Sustainability reporting must be a part of the annual shareholder reporting. Investing community must make their preference and support for companies with sustainability agenda well known.

The ultimate objective of businesses and societies duly supported by governments, markets and investors should be to ensure growth and prosperity through resource protective circular economy than through resource profligate consumption economy. That is the key mindset change, the responsibility and accountability shift and the moving of the needle that must happen towards sustainability.

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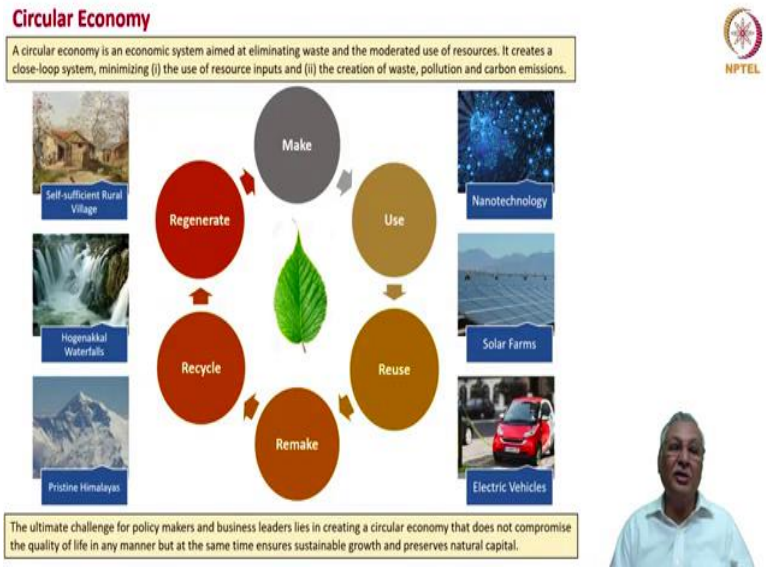

This is a very pictorially elegant and soothing representation of circular economy. What does a circular economy mean? It is an economic system aimed at eliminating waste and having a moderated use of resources. It creates a closed loop system, minimising, one, the use of resources as inputs, and two, minimising the creation of waste, pollution and carbon emissions. That is the meaning of true circular economy.

So, nanotechnology could be one element in the circular economy. Solar farms are another important element. Electric vehicles we discussed in sufficient detail in this lecture as well as in the previous lecture. A self sufficient rural village as the role model for a completely closed loop urban habitat also is an important thing. Waterfalls which provide high level of energy while providing water flow that is another important element of circular economy.

The pristine Himalayas which are preserving the very many plants and materials of biodiversity that is again an example of circular economy. So, we need to make, we need to use, but we also need to reuse, we also need to remake, we need to recycle and regenerate then only we will have a circular economy which is protective of the planet.

The ultimate challenge for policymakers and business leaders lies in creating such a circular economy which also does not compromise the quality of life in any manner, but at the same time the circular economy should ensure sustainable growth and it should

preserve the natural capital which god has given to all of us through the planetary resources.

Thank you.