Strategies for Sustainable Design
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Lecture 35
D4S for Optimization Manufacturing

Hello everyone, in this lecture we will discuss about Design for Sustainability for Optimization of Manufacturing. So, well we know like, in the post industrialised world, manufacturing is one of the actually drivers of the actually this economic model around the world. Most of the countries they want to be like the most industrialised and in order to do so, they are adopting actually technologies ways in which they are sourcing, these non-renewable materials from the like nature, they are investing a huge amount of like energy to process these materials and produce stuff variety of like stuff.

So, in the recent times, we have seen in our one of the previous like lectures about consumerism, where the consumerism, like how the consumerism has increased over the like, these like years and how it has become one of the most thirsty actually area which is looking to satisfy its need, which is looking to satisfy rather its greed, in a like a more, in a mammoth way, so it requires a huge amount of like resources, huge amount of like natural elements such as clean air, water etc and it requires like energy.

So, all of it is going mostly into the manufacturing actually processes and whether it is for like our like a food, whether it is for our like a clothing, whether it is for like providing like a housing or for like other like requirements such as like, for like a health related education related any of like these domain specific or industry specific needs, there is certain actually certain amount of it is like a, coming from this manufacturing actually units, if we talk about these aviation.

So, we have actually aircrafts being manufactured somewhere, if you are talking about these electronics, which we are using and communicating with this actually lecture right now, so these are also being manufactured somewhere, these are using actually n number of synthetic actually, polymers, they are using actually number of like metals, the number of like other like rare earth metals and there is so much actually effort going on into manufacturing actually these days.

And in an overall sense, we have seen in the previous slides how manufacturing and how these sector is responsible for actually global warming potential GWP, how it is responsible for like GHG emission greenhouse gas emissions, how it is responsible for like a carbon

footprint, how it is responsible for actually exceeding the bio capacity of this planet and how it is responsible for creating a mess in the, overall like ecological balance. So, it is very important for us to control this actually sector and go for like, ways through which this can be actually controlled.

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So, if you see like, about sustainable manufacturing system, so it should work actually on the closed loop industry. So, there are some approaches listed down over here on this slide and we will see each of them one by one. So, the first one talks about a sustainable manufacturing. So, optimise processes that minimise negative environmental impacts, conserve energy and natural resources.

This also enhances employee, community and product safety. So, you see, majorly like other economic and environmental aspects of like an ESE aspects of sustainability are involved over here. So, the sustainable manufacturing has the potential to minimise the negative environmental impact, because this is one of the actually major contributors of this like a negative impact on the overall like, ecology of this planet and of course, by reducing the demand of energy by reducing the demand of the resources and the materials, it can help reinstating it can help actually at least preserving what we have, in terms of like the resources on this planet.

So and apart from this, while it has the potential to enhance like, well being of like employees and other stakeholders, the community because the community and the people are important part of this sustainable actually, this whole growth and development actually process. So,

how this sustainable manufacturing can come to the help of this community also and how the product safety also can be actually enhanced in the products, for like a responsible uses.

For example, any like these insecticide, home based like a domestic insecticide we, we use in our like houses for example like a mosquito killer sprays or these things. So, it is clearly like written on the level of these like a products that they have actually certain amount of like a poison in them and are toxic in them and these products must be actually kept away from the like a human eyes and skin must be kept away from the like a children. So, why is it so.

Well this instruction is of course there for the keeping it like a at the safer luxury distance from like a human, from like, from the people. So, this kind of actually responsible of how is it, like is there any way out to actually completely get rid of such like a toxic materials and substances which takes a lot of like effort and resources, for example like for their manufacturing and still they are not safe enough for like, actually in the vicinity of like humans and the babies and the kids.

So, is it possible for like a sustainable means to get rid of these like industrialised products and bring back some more like a ways through which this, the objective of like insect repellent and these things can be actually taken care of. So, this is actually one of the major actually considerations for like a sustainable manufacturing processes. Second optimization of production processes and techniques.

So, production processes are the processes which take, which consumed the most part of the energy required in the industry sector. So, how this can be optimised, so optimise production methods and operations by continuously improving performance, production quality control, fewer production steps, manufacturing innovations like IOT automation, 3D printing, lower production and labour cost and greater efficiency, well there is scope in each and every step of these like production processes and techniques, whether we are talking about the machinery what is being used over there.

If we are talking about the whole technology part like, if you can go into much safer actually or must actually less consuming like a technology for like energy and resources, if we go for like a newer technology such as like IOT automation and 3D printing, so 3D printing has immense potential which can be, like a still utilised, which can still be like explored in n number of ways to go for like a sustainable actually manufacturing processes.

So, 3D printing as we know of is like a, additive actually manufacturing process, where the waste of the material is minimised up to like a greater extent and it does not actually waste like material. For example, when we construct or any like other like artefacts from a piece of like a wood or metal, we utilise actually methods of like machining etc and we end up actually wasting a lot of material from the that block to carve out the particular part what we wanted.

For example, if we want to kind of maybe some object to, some object we can actually sculpt from that actually block of the material. So, this 3D printing actually prints that block that entity only whatever we wanted, removing completely the rest of the wastage actually part which usually the, this reductive actually fabrication method actually reductive this construction method actually uses.

So, we see like, there is a huge potential of, in these actually technologies to be applied in our like a design and construction actually exercises. So, utilising these new technologies could also be like a strategy, where we are actually we can use such like a techniques for like greater efficiency. So, this could be used for like, even reducing like labour cost, even reducing the time consumed in like fabricating these like a products or constructing these projects.

So, time is also one of the major considerations today, which are we can actually optimise on. So, we are talking about in the next level about increased energy efficiency. So, this low and clean renewable energy consumption minimise energy uses in production. So, this energy is one of the very important entities today for the, which is coming, which has come to actually help of this, entire growth and development model.

So and we are aware of like a building sector itself consumes around 40 percent of the total energy produced in the entire world. So, this is the largest and the major share which this sector actually has grabbed. So, how this energy consumption can be minimised. So, this is also one of the actually important strategies which we can adopt for the overall actually sustainable like achieving these goals.

Further lower producing less pollution, emission and waste of course, there is a lot of mess which has already happened in the entire ecosystem in the air or water, earth and most of these places. So, how this can be actually minimised? How the these resources should be actually taken away from becoming or polluting our toxic agent in the nature, I think that should be the focus of today's actually design exercise.

So, like producing like a low waste disposal actually materials to reduce the, these like costs of which are happening due to the pollution, cleaner and safer working environment and also creating actually places comfortable spaces, where one can actually work in like a healthy environment.

So, one of the actually STGs like a target is to create actually maintain the health and well-being of the local community also. So, how this point can help in that STG also is very interesting to see over here. Further, like industrial symbiosis, like industrial symbiosis, emulates sustainable natural cycles in industrial networks, where all discarded materials from one industry are they become the actual resource for the others to use, industry for actually production systems prototyping, new manufacturing setup.

It talks about two major points over here. The first one is to like close the actually a cycle of any like a product. So, if there is any like a by-product or in like a waste material, so the process should be developed so that, that actually waste or that actually by-product should become a raw material for some other actually process. That is why that is how actually we may be able to close the loop.

So, this is one of the very important actually aspects mentioned over here, like to go for like industrial symbiosis. Further like industry 4 production systems. So, industry 4 actually this uses lot of integration with the like IOT Internet of Things and other like networks, on this 3D printing and sort of like this AI ML based actually calculations and algorithms. So, with the incorporation of like a high degree of these emerging actually technologies, how the efficiency can be actually achieved is the matter of discussion over here.

The last point over here is the like a design for remanufacturing. So, this assembling into like useful parts, so that it can be directly used into another product improvement around actually its assembly, reparability, refurbishment this assembly. So, this we have, these points we have discussed in the three Rs chapter.

So, why it is very important for designing for the like a disassembly, designing for actually dismantling designing for remanufacturing, designing for reuse, because this disposal and actually throwing of any like as simple as that throwing of any material into the nature and without actually properly disposing of it is a crime, which we are actually committing with the nature. So, this must actually stop at the urgent basis and then we must actually design each and everything, which should follow one of these approaches, one of these actually strategies in order to minimise impact. So, let us move to the next slide over here.

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So, how this a manufacturing optimization can be actually brought and what could be the actually benefits out of this exercise. So, increase machine and people utilisation, increased machine and process output and decrease time to resolve faults, decreased operational process buffers, decrease instances of recurring problems.

So, you see like, there are several actually benefits of this process optimization, this manufacturing optimization in the like a manufacturing sector. So, there is always like an efficiency which can be actually brought, whether it is on time, whether it is on resources, whether it is on energy, whether it is reducing the number of instances of failure and reparability etc. So, well there are advantages only, overall which can actually result into benefit actually for the (())(14:33).

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So, the processes if you see of the like manufacturing optimization, so here we can see like a specify the required visualisation and system integration with the enterprise system. Align the digital twin with visualisation integration to provide the required information. Third tune the analytics algorithms to generate the status and insight information required for the digital trend and add data sources to support analytics, modify and create data sources to provide the required data inputs to the analytics.

Extend IOT infrastructure as required with gateways, sponsors etc to generate the required data. Finally, provide manufacturing optimization as a fully managed service following an initial POC. So, you see like a how this thing can be done is not very complicated, it is not very actually rocket science, but yes with like a proper intent with a justified purpose, with the actually pious intent and some efforts this can be easily done and this would certainly will lead to this optimization and achieving actually efficiency on like a several actually fronts.

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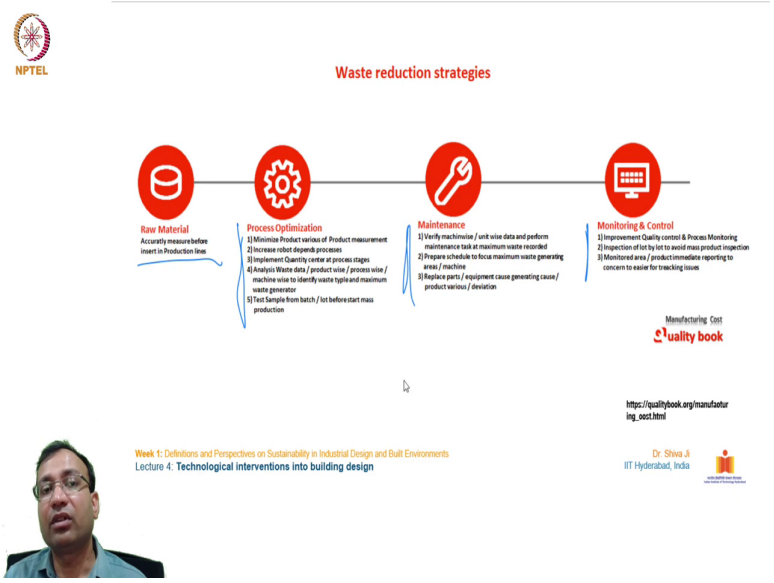

So, how these waste reduction strategies can also be formulated around this actually manufacturing like processes. So, we can see in these many efforts starting from the raw material, I accurately measure before insert in the production line. So, as simple as that, it is not something very difficult to understand.

So, the wastage of the material can be minimised right there, when we are actually giving the input of that material into the actual manufacturing process. Secondly, on the process optimization path minimize the product various of like a product measurements, increase robot depends on the processes and implement quantity is centred at process stages, analysis based data product wise, process wise, machine wise to identify waste types and maximum actually waste generator.

Finally, like a test sample from like batches, a lot before starting like mass production. So, these are also very small and easy to understand final points, which may result into better optimization of the process itself. On the (())(16:43) on on the maintenance side if you see, like verify machine wise, unit wise data and perform maintenance task at maximum waste recorded and also if we have this data like our how much was the maximum waste generated at any given machine at what capacity, then we can go back and reengineer this to minimise actually waste. So, that there is very little actually output on the like a waste part.

Second like a prepare schedule to focus maximum waste generating areas machines, third like replace parts equipment cause generating causes product various deviations etc. So, these are

the actually final points over here we can see about like, how this maintenance can be taken care of by going for like repairs, going for like a preventive check-ups etc of the like system.

Finally, on the monitoring and control part improvement of quality control and process monitoring, inspection of lot, by lot to avoid like mass production inspection on a third monitored area or product immediate reporting to concern to easier, for like tracking actually the issues.

So, you see on this monitoring and the control part also there is a lot much which can be done and this is actually final stage where some more actually quality control and quality checks can be brought in to minimise the actually return to actually factory of the faulty and defective products resulting into like a saving of a lot of like resources, material time and energy etc. So, on all stages of this like a production, if we adopt like a waste actually reducing like a strategy. So, there is always like a immense possibility to improve on these actually factors

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Finally, on the like a process optimization, we can go for like the mapping of the entire process, we can go for the process identification, identifying which process to improve, we can go for actually footprint and planning etc, developing your own plans and define source footprint for the manufacturing actually floor analysis documentation, design, results, analysis part and then finally, like the lean manufacturing accountability and sustainability at plant entry level and improve plans for the cost.

So, these are very standard actually typical procedures for like any optimization processes also. So, by complying these with these actually (())(19:11) high degree could result into optimization on the manufacturing front.

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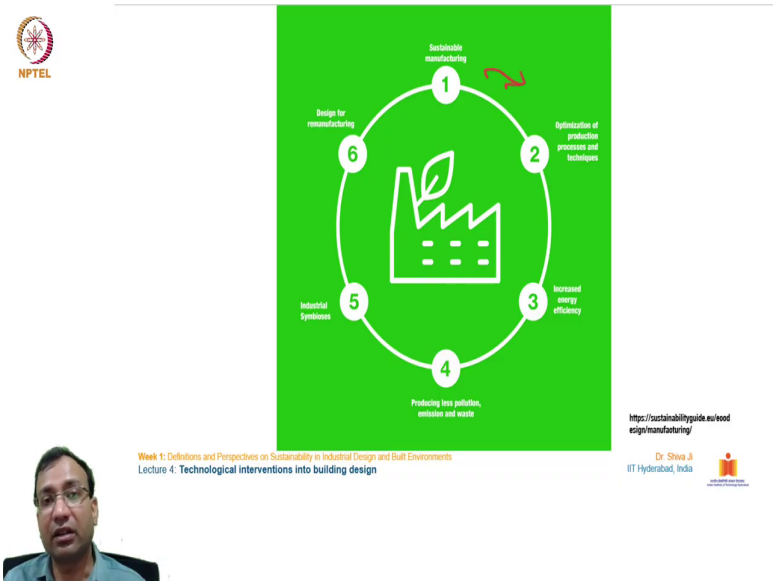

So, here if you see on this slide, this slide talks about this fashion in like a cyclic way. So, how the sustainable manufacturing leads to like optimization of like a processes in production and techniques that will lead to the increased actually energy efficiency of the like a overall actually demand which that industry unit is actually putting up, finally resulting into like a producing like a less pollution, emissions and waste, finally like establishing an industrial actually some biases and design for like remanufacturing.

Again, like, we should actually be able to handle like our like by-products and the outputs, so that they become actually part of like a cradle to cradle actually approach and then we can again go back to starting like a sustainable manufacturing. So, this we can close the circle and complete the life stages of any product into a complete like a closed actually circle.

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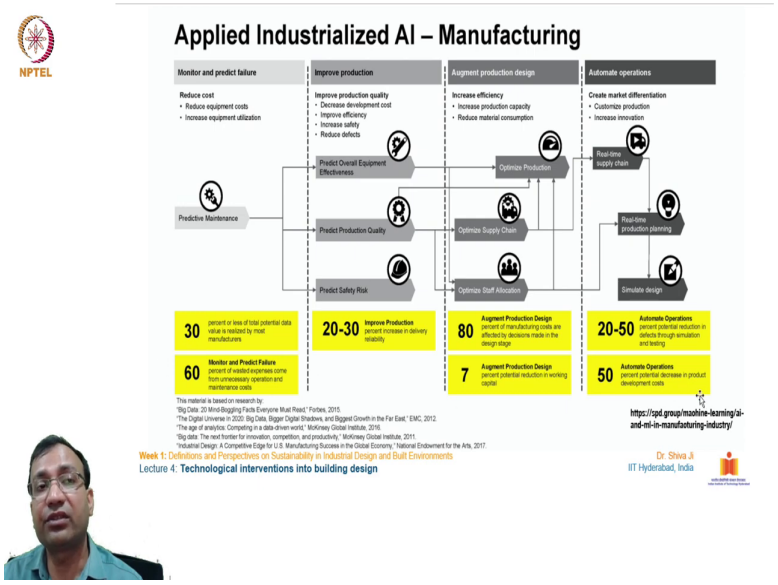

Coming down to the next part, this is actually a model given over here for like a applied industrialised like AI in manufacturing sector we will discuss one by one. So, this is divided into like a four column so you can see over here, so first one belongs to like a monitoring and predict failure and second in the improve productions. Third is for like augment production like design. Finally, like automate operations.

So, in these stages, what could be the strategies for like a improvement which we can adopt for the overall actually efficiency to increase the efficiency in the manufacturing sector. So, here we are talking about like a reducing cost, reduce actually equipment costs increase like equipment utilisation, so that will result into obviously, like a reduced cost for the overall like a system over here and you go for actually pre-predictive maintenance.

Before and before actually the system goes for the failure, we must actually undertake preventive maintenance, in order to reduce the idle time and in order to actually minimise the actually waste of the time factor, of these like a heavy prized machineries So, for that improve in the second column, for improving like others production system, we can go for improve production quality, by decreasing the development cost by improving the efficiency increase safety player measures, reducing the defects and around this predictive maintenance part there are three points given over here.

Predicting overall equipment effectiveness, predicting production quality, predictor safety risks, the which will in turn again like a further give, actually this, actually lead to optimising like a production, these two are leading to the optimising production this second one is

leading to optimising like a supply chain and optimising like a staff or location. So, we see like, there are three like a further like effects of like taking these like this predictive actually maintenance activities.

So, in this augment production design, so we can increase actually efficiency of the entire this machinery and this equipment set up the documents and tools being used and also increasing like a production capacity this way, we can actually reduce the material consumption also Finally, in the automate operations part, create market differentiation customised production increase innovation.

So, with these actually this initiative of this product, predictive mentioned in my maintenance as a resultant at this stage, we can actually go for checking the real life actually supply chain, further we can go for like a real time production planning and we can overall in an overall sense, we can simulate the design and we can actually rework our if there are any like lacunae or any like a shortcomings.

So, in an overall sense, if you see in this yellow part 30 percent or less of total potential data value is realised by most manufacturers. So, the see, the in terms of the data shown through these like our columns over here like how much of potential is available in each of these actually columns 60 monitor and predict failure.

So, the 60 percent of like a wasted expenses, come from unnecessary operation and maintenance costs. So, how these costs can be actually minimised, this is one of the actually opportunity in here, whereas there is a huge scope of like improvement. Further, improvement of production 20 to 30 percent actually increase in delivery, reliability can be actually attained through these measures, which are happening in this actually column.

Further like, for the augmenting production design 80 percent of manufacturing costs are affected by decisions made in the design stage only and next like augmentation, augmenting actually production design. So, 7 percent potential reduction in working capital. So, see, these are actually, they are not actually small numbers if we consider the like a, the volume of actually resources and energy and things utilised by these sectors in overall actually output these quantities will be immense, very huge and here we see like the kind of amount as the kind of figure we are seeing over here, this is talking about like 80 percent of manufacturing costs are affected by decisions made in the design stage only.

So, design stage is very critical, design stage is very important actually, how things are going to turn up, in the like operation stage. So, we must actually take care of these design stage in order to minimise the risks involved, which may occur, which are in the tune of like, up to like 80 percent, which is immense.

So, finally, in this stage if you see for automating actually operations to 20 to 50 percent potential reduction in defects through like a simulation and testing which is also used, first of all it adds to the like customers like a confidence in the product or whatever is being manufactured and it increases the actually brand value and plus it helps reducing the costs of like a repair, replacement and refurbishing etc.

So, helping into like minimising the overall actually conjunction by the company. Finally, like for automating operations, we can see 50 percent potential decrease in product development costs also possible through actually automating the operations. So, there are a lot of like, improvement areas, we saw actually through this slide, in like a manufacturing sector.

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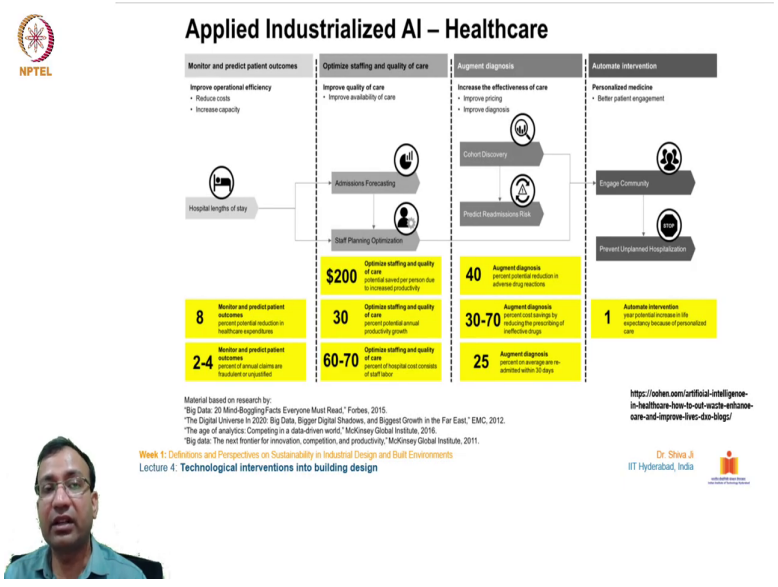

Further see this next table over here, this talks about applied industrialised AI in healthcare sector. So, the how this AI is going to help for this healthcare, we will see this table one by one. So, the first column, so suggest about a monitoring and predicting patient outcomes. So, improving like operational efficiency, reducing cost and increasing capacity of course and one like a hospital length of stay if you see from like this stage in the like a second column.

So, we will see like optimising the column talks about optimising staffing and quality of care. So, improving quality of care improving like a availability of care. So, with this actually hospital length of stay, admission forecasting like how much, how many actually number of patients or intakes will be there, will be happening and then planning the staff actually members for like an optimised actually working in an efficient way.

So, this will lead to, lead to certain like a chain reaction in the next actually column. So, here if you see, in the augment diagnosis stage, increase the effectiveness of care. So, the improving like a pricing, improving like a diagnosis, which will result into like a, with these initiatives like a cohort discovery and predict readmission risks, like if there are any. So, this model actually helps in understanding like are what are going to the conditions of the patient and in what ways like, the hospital may have to deal with them, if situation like are improves or if situation does not improve if they need to, like a readmission or something.

Finally, in the fourth column, if you see automating intervention. So, automate intervention part like a personalised medicine, better patient engagement, so that customised actually, medicine services customised actually medical service can be extended to the patients and also with these actually effort of these activities engaging with the community will increase in violent tone, it will actually prevent unplanned hospitalisation it will end up into an increased actually well-being and betterment of the like a patient and the community in overall sense.

So, in the numbers if you see like a monitor and predict patient outcomes, so the 8 percent potential reduction in the healthcare expenditure is like expected through this actually modelling, on the monitoring and prediction patient outcomes. So, like 2 to 4 percent of annual claims are fraudulent or unjustified.

So, this also can be actually prevented further like 200 dollars like a potential saving per person due to increase like a productivity. So, this is also, this can be achieved through like optimising staffing and quality of care, further on this like a 30 percent potential annual productivity growth can be achieved, further on to the 60 to 70 percent of hospital cost consists of like a staff labour.

So, this can be actually minimised significantly or at least optimised for like a better output. So, this modelling would be very helpful in actually optimising the staff of the local hospital. Further on the augment diagnosis 40 percent of potential reduction in adverse drug reactions,

30 to 70 percent cost savings by reducing the prescribing of ineffective drugs and 25 percent on average are like readmitted within 30 days.

So, this also can be prevented. So, this is actually a help through this predictive modelling like how hospital can plan its resources, resources of the like, the availability of beds, the resources of the like a staff, doctors and nurses and other like care taking like a persons, for like increased efficiency.

Finally, on the automated intervention, like the column over here, we can see like a one year potential increase in life expectancy because of personalised care. So, this is a one of the way like a huge achievements, which are medical actually fraternity can give to the humanity right now, like an increased actually life actually potential. So, we have been like a seeing with the improvement in the health sector over the, like a last several decades and the last like a century, like how much of the life expectancy has actually increased and further like these modelling and optimization processes will boost this figure up.

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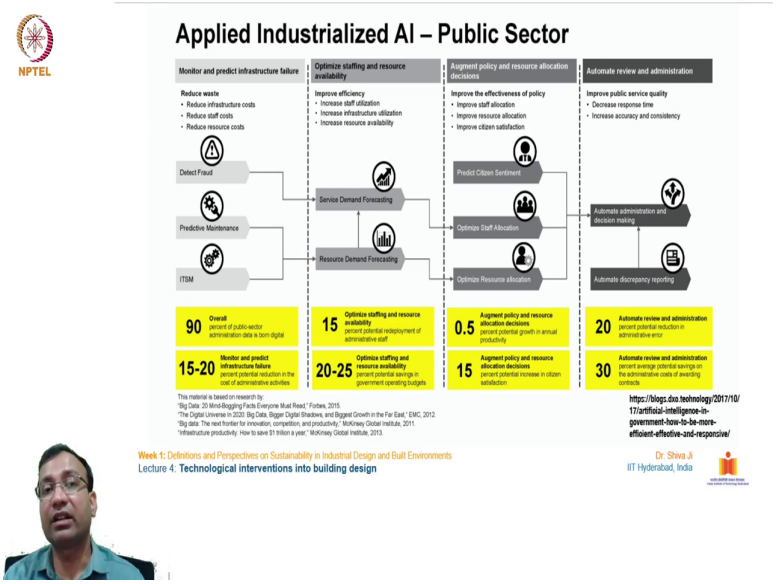

In the next and last slide of this actually lecture, we will see about this applied industrialised AI system in the public sector over here. So, in this the public sector we have again like these four columns, so we will try analysing these. So, on the first column talks about monitoring and predicting like infrastructure failure, reducing like waste. So, reducing like infrastructure costs, reducing staff costs, reducing like resource costs.

These are actually measures which can be like taken off for like, further like improvement like detecting fraud and if it is happening at certain level, predictive maintenance and ITSM.

Further in the next column if you see like optimising staffing and resource availability, improving efficiency increased staff utilisation, increased infrastructure utilisation, increased like resource availability.

In the next point, if you see with the help of the these points undertaking in the previous like a column, we can go for actually service demand forecasting. So, these actually productive modelling, this projection can be actually drawn for actually creating a model for like demand forecasting, which are going to actually happen in the local public sector and resource demand forecasting, yes.

The third column if you see like augment policy and resource allocation decisions, improve the effectiveness of policy, improve staff allocation, resource allocation, citizen satisfaction in an overall sense. So, this model, this actually predictive, like these steps will lead to like optimise resource allocation, staff allocation or citizens like a sentiment. So, then improved actually efficiency of this infrastructure and reparability and maintainability will lead to the positive impression in the mind-set of the like community and the public at large, improving the actually the image of the like of public sector.

Finally, in the fourth column, if you see this is about automating review and administration. So, here we are talking about improving public service quality decreased like response time, increase like accuracy and consistency. So, these are the two major actually areas of concern as far as like a public interaction is concerned, because the service must be actually rendered within the satisfactory actually time limit, for the like of persons to feel that yes, they have been like, taken care of their problems are actually addressed and secondly, like increasing like accuracy and consistency.

So, there is minimum chances of like an error or mistakes happening in the entire system. So, with this we can see in then this stage, like automating the administration and decision making processes and also that efficient way these things can work actually. Finally, in the numbers, we will see like in an overall actually since 90 percent of public sector administration data is like born actually are digital monitoring and predictive infrastructure for 15 to 20 percent potential reduction in the cost of administrative activities are possible through this, like a measures for like detecting fraud before any or going for predictive maintenance etc.

Finally, in the second column, like optimising staffing and resource availability 15 percent potential deployment of the administrative staff and 20 to 25 percent potential savings in

government operating budgets are possible. Further like if you see 0.5 percent potential growth in annual productivity can also actually take place. So, considering the huge budget and amount of actually, investment needed for maintaining and executing these infrastructure projects, smaller improvement in the optimization, at the scale of like 0.5 percent also will result into, saving in the like multi like a crore of rupees and the money invested in the public sector.

Next 15 percent actually potential increase in citizen satisfaction level also with this improved actually transparent actually processes as far as like the when the public interaction is concerned in the public sector. Finally, in the fourth column 20 percent potential reduction in administration error is also possible, avoiding actually such like errors and mistakes, through this AI modelling and 30 percent average potential savings in the administrative cost of like awarding contracts also is possible because this is one of the key areas where like, this public sector awards actually contracts to the contractors, who execute certain like a works.

So this system will also help further optimising the overall actually ecosystem in the like a public sector. So, we understood through this lecture like how this process optimization, how the optimization in manufacturing, how the process optimization can help in reducing the resource consumption and reducing the energy costs and optimising actually the resources whatever we have to the maximum like a potential, in order to minimise the impact on the ecosystems.

So, we must actually use these methods of like optimization strategies in our like designs in our like a system design projects to improve on the overall efficiency. With this, I would like to bring an end to this lecture. So, thank you, everyone.