Introduction to System Dynamics Modeling
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Introduction
Lecture – 1.2
Systems Thinking and System Dynamics

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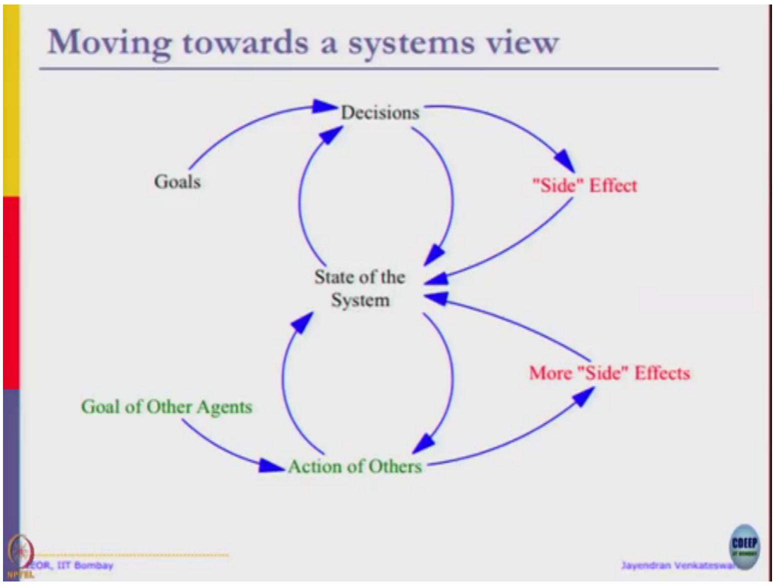

So, moving towards the systems view I need to change the slide. So, we have goals, based on the goals take decisions that influence state of system that are all again is just an curved diagram of the same linear diagram we saw a couple of minutes, I mean a few minutes ago. This was is this alone is not enough. We do not have abstract goals. The goals are always relative to the state of the system.

So, based on the state and based on that and the goals based on the gaps, we take the decisions. But as soon as you take decisions that is going to affect the state of a system which will forces to make more decisions in future and what are the decisions that we take. We will have effects sometimes you call it side effects because we are not planned for it, we are not thought of it, we are not anticipated it.

May be we were just we did not know or maybe we were just ignorant or maybe you are just too lazy saying that if you are considering all that will make my life more difficult. So, let me just ignore all that. It could be any of the reason, but whatever it is if you take decision it will have effects sometimes you call it side effects, but it still affects.

Unfortunately you are only the player in the system. So, state of system also affects the action of others and others have goals. If the simple example is you are registering for a course if not that only you are going to register for a course and if course has a limit and you told your friend that I am going to register for this course, suddenly you find that your entire batch is registered for same course and before you could do it limit as it probably it was your idea to do that course in the first place, but it is already existed.

So, your goal is unmade and they will also have more side effects this is what. So, as you move to systems view, it is not there. For every problem we need to go and model the entire world. We need to look at what are the things that can influence, that can affect and if it is too much and learned to draw boundary for the system and considered as much elements as required to address, the issue in a little more fundamental manner.

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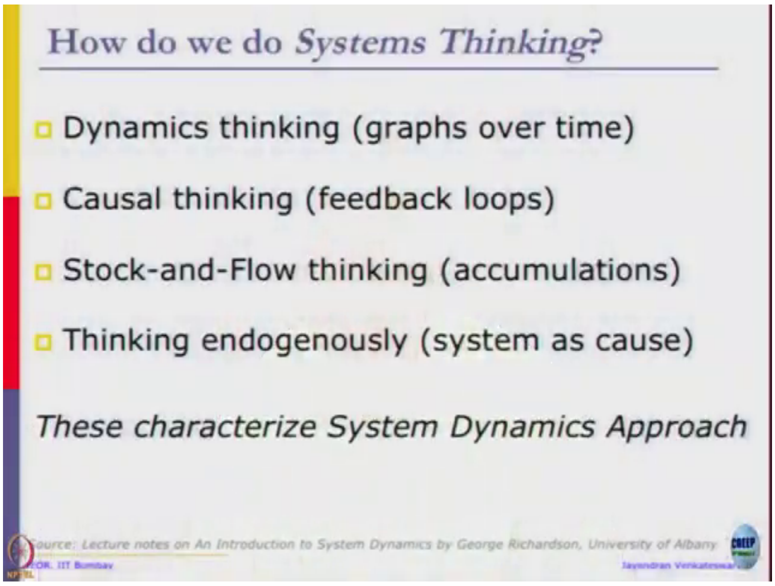

So how to do systems thinking? First we are going to learn this act of thinking dynamic view because it is called system dynamics. So, we have to do and dynamics means behavior over time. How things are evolving over time we are familiar with the concept, we are familiar with events. One thing that we are not familiar is as soon as a problem is presented, we should say what is happening over a time if it is there is an unemployment is like is that to your 8 percent, ok.

That is fine. Let me see is how is unemployment has been behaving over the last 10 years of 10 years 20 years and how do you think it should behave in the future. So, let us try to understand what kind of dynamics that we want to create because it is not a onetime thing, it is over time. What are the decisions you are going to make is going to have an impact over a time and there is and there is a lot to learn from some what is happening in the past. So, we are going to cultivate this thinking dynamic the terms of dynamics of various variables.

Second is a causal thinking. Thinking in terms of effect cause and effects you are going to identify some variables and see whether that has an effect on something else or does it costs some other effect identifying, is there any potential feedbacks within the system, what are the delays that is happening in the system. So, we can start explicitly identifying them once you are there.

Then we will also learn how to do public called as stock and flow modeling where we start to think of things as accumulations. So, whatever we that can I am like even if I stock say a to reduce say the total pollution within the lake of power, I can say let me ensure that no sewage water enters the lake, but already there is so much sewage water already entered the lake already, so many pollutions already entered the lake right.

So, that has accumulated over the years just because it turned off the sewage today does not mean that that is going to disappear. So, that becomes more apparent as you start looking at things as accumulations. It is getting accumulated somewhere. There has to be mass balance. We are used to mass balance in a more compact statics, but that is true for environmental systems, also social systems. Also there is already a accumulation of things. It can be physical like pollution level or it can be even what can I say mental models or beliefs over time people have been lead to beliefs and things.

You cannot just send one news article or one announcement saying that from today you have to do like this. You cannot change peoples belief systems. So, immediately peoples beliefs are accumulated over a time. So, only it will take time to change that belief and replace it with some other whatever beliefs right or wrong. So, that is what we mean by stock and flows. Let us see there is a stock of things and finally, thinking endogenously I mean systems as a cause we are used to attributing various things as an external factor.

It is not my fault. It is these things are beyond my control it because the competitor deduct it because somebody else did it. So, once you start blaming others, then you do not have any leverage. If I want to control and if I want to run it effect to operation or make good decisions, then you have to ensure that all the variables are endogenous to the system, right.

If its demand is external, then demand is external, then how it happens, why it happens you do not know, but in a say endogenous is ok. Can I do some pricing schemes which will influence demand that also you might have thought. So, when you do pricing, demand will get affected. So, now suddenly demand is not anymore exogenous, it is endogenous to a system because it is reacting to some decisions that you are taking which is in your country. So, we try to look at it endogenously.

That has been clearly characterized and left. So, we have to understand it ok. These are external and these are endogenous. Third is like this in real reality things can actually be affected externally as well as in endogenously, but we believe that some are it is not affected endogenously it or not are only effected, so endogenously or exogenously. So, a if it is indeed like endogenous, then we need to identify it and later we found that no it is not endogenous, then we will leave it ok. It is you need exogenous will be more.

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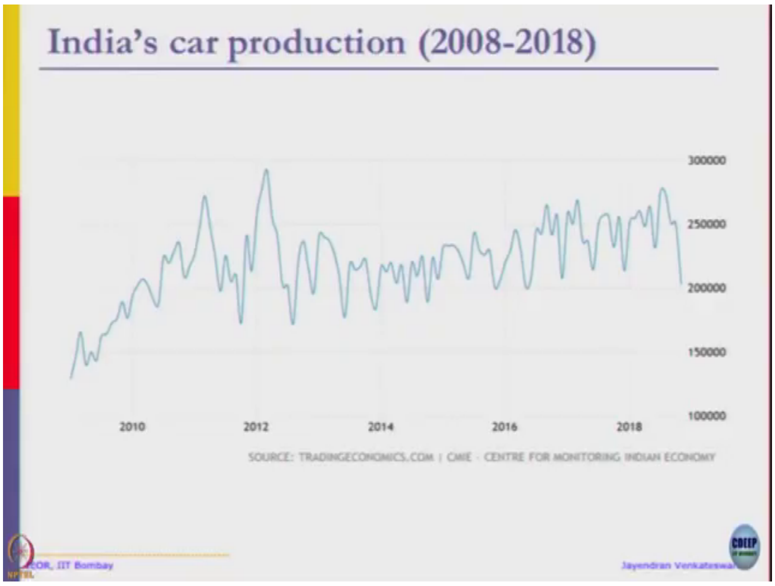

This is characterized system dynamics approach. Just to give a brief example when I say dynamics, this is what I mean. We look at the behavior over time. This is a on the trading. Economics are common in India car production in the last 10 years. You can see there has been it is a kind of a not a steep, but steady growth and also you can observe cycles, you can observe standards cycles of same sizes it is going to anticipate.

So, this is your manager in charge of whatever in the last quarter sale is going to dip, you better bounce back right. So, now that will rule some regulations or what has been happening for us to improve.

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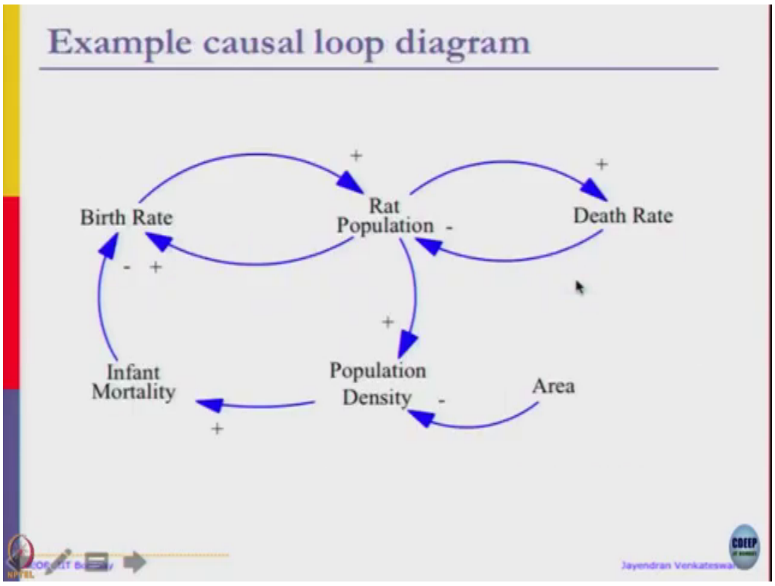

So, this was the example of a simple causal loop diagram. This example is on a Rat population. We are looking at is a rat population is affected by the birth rate and it is affected by the death rate also, population also affects it and affects the birth rate, birth rate also affects the population. And in this example the population also affects the of course the density given that area here is assume to the external, then you do not have any control. Rats cannot migrate.

They are fixed in that area. So, here this is the example of an exogenous variable and here it is assumed density influences your mortality which affects your birth rate. These kind of diagrams are helpful to understand what are the variables in system, how they are linked to each other. There are no equations in this model as of now.

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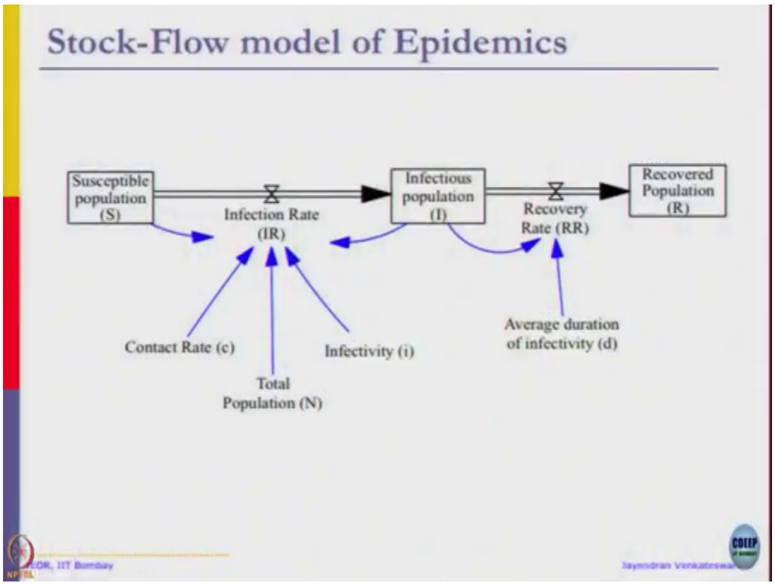

See we move on this is what is called as stock flow model where these rectangles are called as stocks. They accumulate things over time and they are affected by the flows shown by thick arrows with a valve infection rate. So, there are susceptible population who get infected with some disease.

They can put this mean infectious population who after they recover become recovered population. So, in this diagram the total population is conserved, the populations of suppose you start with whatever 100 people either they are too susceptible at some point. If they get infected say 10 people get infected, this becomes 90 and this becomes 10 and when they start recovering suppose 2 people recovered this becomes 8 and this becomes 2.

So, that total people gets conserved, they do not just disappear from the system, right. So, that is conservation of a mass. So when you move to this, we will move into this equation relating them it need not be simple addition. It can be what are the types of relation that is required between the various variables.

Since all are engineers, the underlying equations are all differential equations. So, we can nicely model it once you have the equations and if it happens in linear models, various linear systems theories can be applied and what are the methods we learned to analyze a differential equations can be adopted here to understand and solve, but in most of the in all the other causes you would have learned only in with x y and z various Greek alphabets and Roman numerals.

I mean Roman letters x y z in differentiation in double differentiation and all those things. So, difficult and challenging part is identifying with the variables contact rate, total population infectivity, what are all those things and then coming up the equations and then once you have this structure and finite linear, then we can solve it if it is non-linear, then we do a research to lot of simulations under we will be stricting ourselves to simulations and towards ends of we will be looking at some for specific say scenarios. We can look at what kind of control theory approaches can be used.

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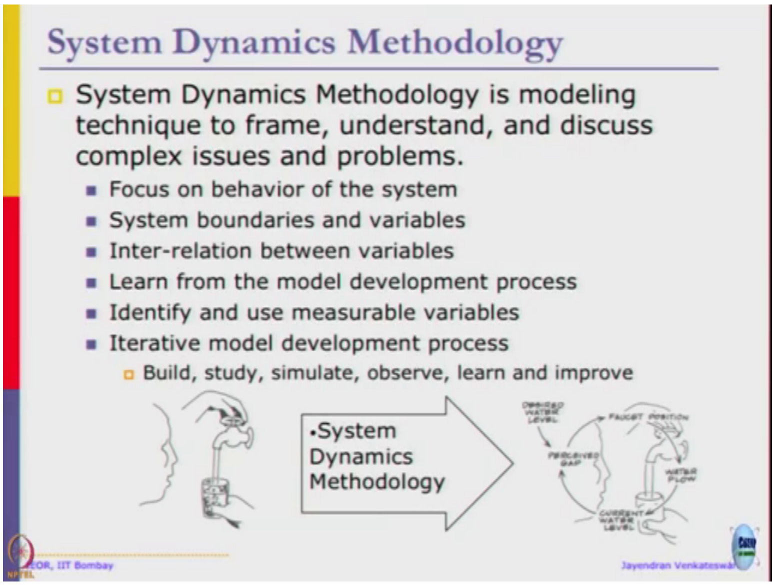

So, system dynamic methodology is modeling technique to frame, understand, discuss complex issues and problems. They are going to be focused on behavioral system. We are going to look at system boundaries, interrelationships, learn from the model development process itself.

So, that is a biggest learning the also that you will get till now given a problem we can solve part of these exercise and learning in this course is how do you figure out and understand and draw the boundaries of all the problem, how to identify the variables, how to identify relationship between that.

Once you have that causal map that itself is the big learning till now nobody has shown the links and it is a as try to understand what affects what. So, even coming up with that itself is a learning process. It is not that it has to be simulated just coming on causal map and then building the simulation and then trying to analyze.

So, taking any physical or economic or social environment phenomenas, we will write and apply system dynamics methodology. So, we can that there is some models out it appropriate models and further to understand.

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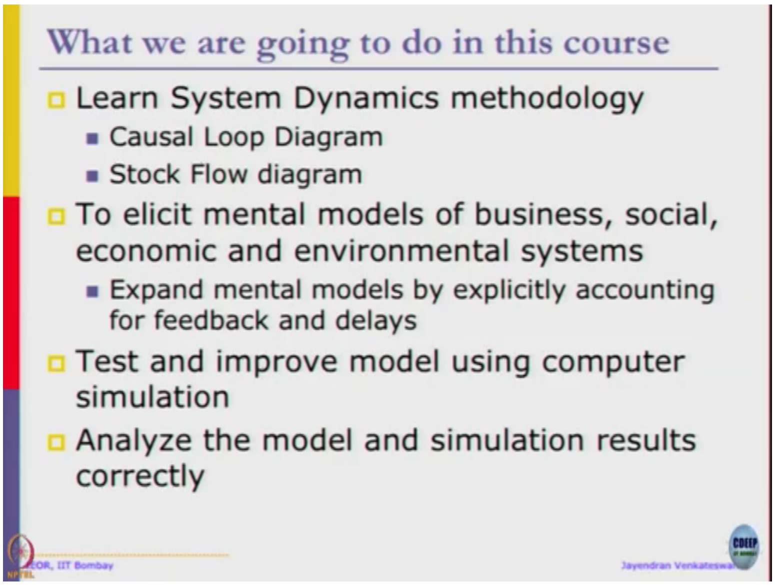

So, now course we are going to learn causal loop diagram and stock flow diagrams, we are going to elicit mental models of business, social-economic environmental systems, explicitly accounting of feedback and delays test and improve the model using computer simulation analyze, the model and simulation results correctly it is not enough to build a model. We need to actually analyze it.

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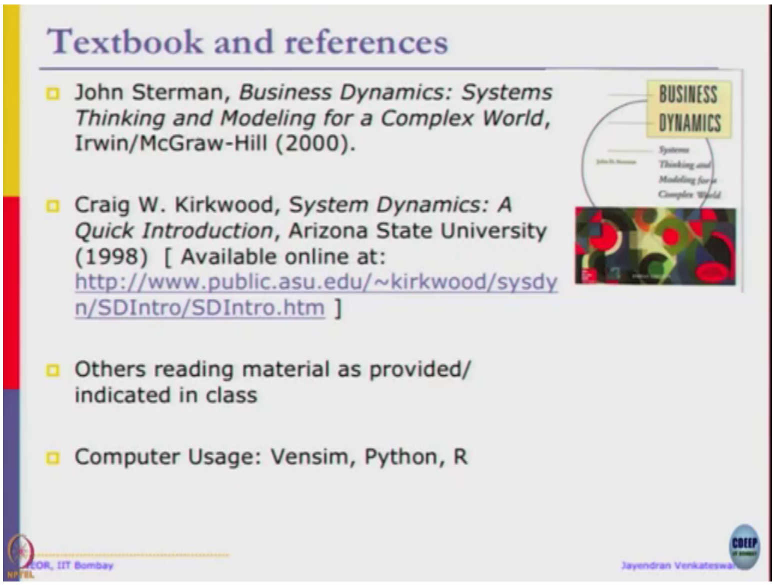

So, this is a very popular book by Sterman, Business Dynamics, we will be following most are those. The title say Business Dynamics. It has lot of models on environment and social systems also. So, big fat book Kirkwood has put up some nice notes and system dynamics online it is free. You can take a look at that if on basic concepts are quite easy, the challenges when we try to apply those basic concepts in actually trying to build a model of an system that we are studying that is challenging.

Other reading material provide I will I will give you links to appropriate notes or whatever I write or whatever what are slides you put it will be a we will be using Vensim and when it some Python and RF simulation become the large. Now towards the end of the course I will teach for large models, how do you do better analysis. So, we will be using computers.