Natural Resources Management (NRM)
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Lecture - 34
Modeling and Simulation Application in Agriculture for NRM Part – 2

So, continuing from last class on modeling and simulation applications in agriculture for natural resource management, so, today, we will discuss further on that particular topic.

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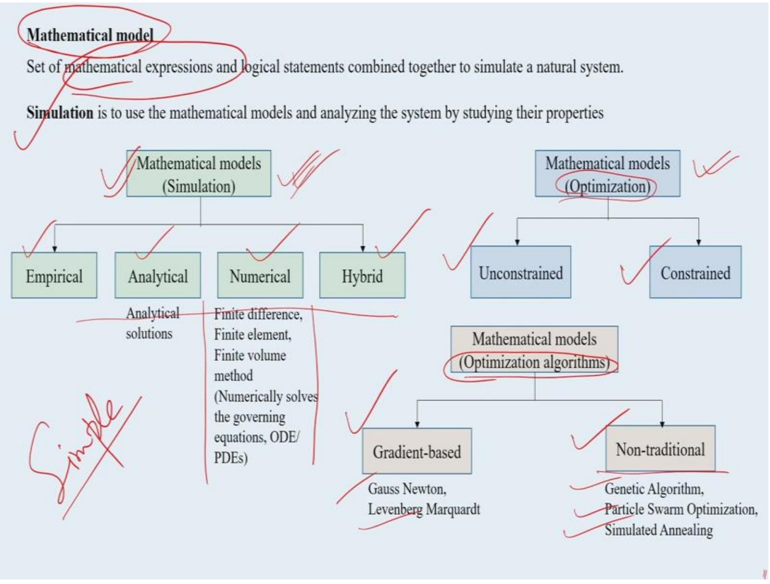

So, in the last lecture, we discussed about mathematical model, if you recall. We also discussed about that two type of mathematical models, simulation and optimizations and then under both this type of model we have different, different kind of sub model functions and types. And then finally, we discussed about also the optimization algorithms, gradient based and non-traditional algorithms.

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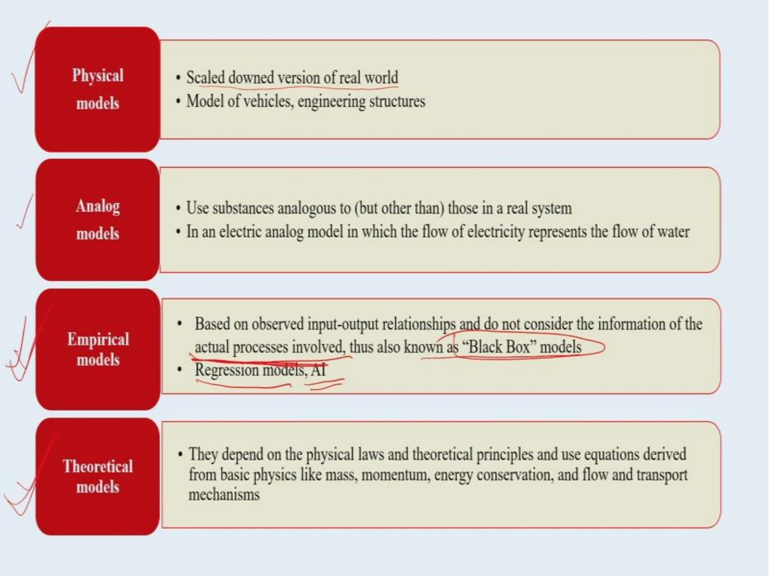

So, following this today, we will also look into the other models like physical model, analog model, empirical model, theoretical model. So, in physical models basically, what we do? We try to utilize the scaled down version of the real world. In the previous lecture, if you recall that I discussed that modeling often try to actually mimic what is happening in the natural system. I also mentioned that 100 percent mimicking of a natural ecosystem or processes almost impossible, but effort is always made to go as close as possible to the real situation in the nature.

So, in physical models is a scaled down version of the real world and different type of engineering structure related models, model of vehicles these actually comes under physical models, where largely we try to mimic the conditions what is happening in natural in real world on the physical nature system and that model we call as physical model.

The next is your analog model. In case of analog model, it uses the substances analogous to those in a real system in a suppose electric analog model in which the flow of electricity will represent the flow of water. So, in analog model we try to actually model which is analogous to the real system.

Third one is empirical model. In case of empirical model these are largely based on observed input output relationship and they do not consider the information of the actual process which are involved for any purposes in the natural system. And that is why they are known as Black Box model. Few example like regression models, artificial intelligence; they come under empirical models.

Then theoretical models. In theoretical models, they depend on the physical and also theoretical principles and in case of theoretical model we use equations which are derived from basic physic like mass, momentum, energy conservation, flow and transport mechanisms. So, on those mechanisms or principles theoretical model largely are based on. So, it is clear. So, we have discussed mathematical models, then physical analog model, empirical model and theoretical model.

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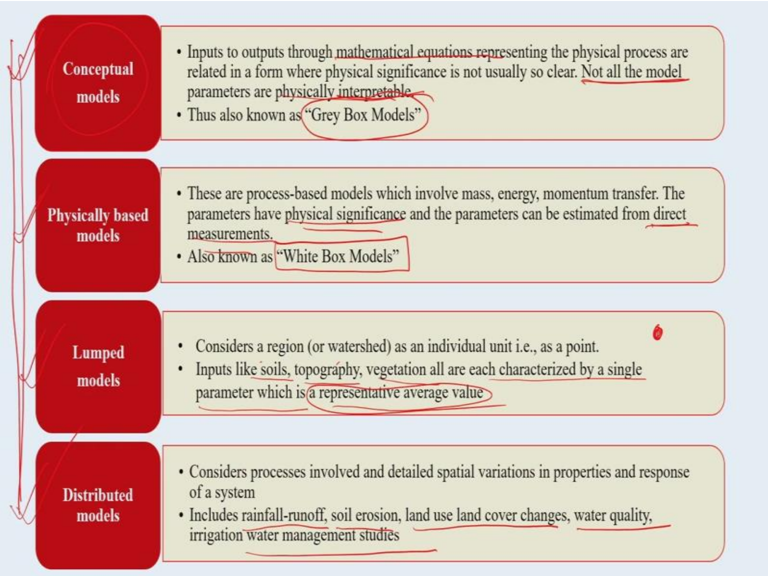

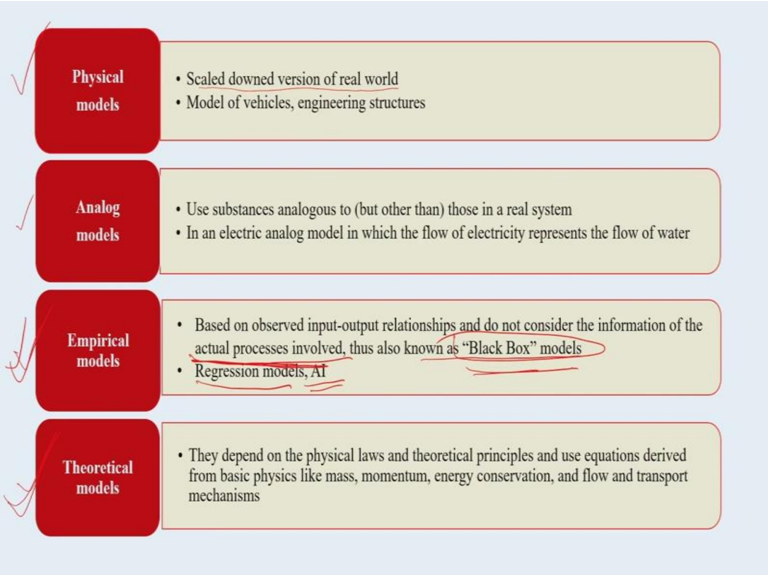

Next conceptual model, means, when you conceptualize about a conditions or a combination of conditions in a particular system, here inputs to outputs, the function takes place through mathematical equations, which represent the physical processes, which are related in a form where physical significance is not easily so clear or visible. Not all the model that you can think in case of conceptual model, not all the model parameters are physically interpretable you cannot physically interpret them and that is why they are known as Gray Box Model.

Just now, we discussed about black box model right here, in case of empirical model. Now, here we get in case of conceptual model, it is known as gray box model. Why, because physically not all the parameters that you use are interpretable.

Now, next is Physically based models. physically based models, these are process based models, which involve mass, energy, momentum transfer, which continuously happening in our ecosystem. The parameters have physical significance and they can be estimated from direct measurement, that is important here. The parameters which you will be using for physically based models they can directly be measured. So, they call as known as White Box models.

So, once again I repeat we got black box model in empirical model, we got gray box model under conceptual model, now, we got white box model under physically based models. So, these are actually popular term among the modeling and simulation community.

Next lumped model. You might not have heard much about lumped model, but we should know that these kind of models they consider a region suppose a watershed region or agricultural field as an individual unit, that is as a point. What are the inputs are used for these kinds of models? Soils, topography, vegetation. All of them are characterized by a single parameter which is representative of average value. So, each one of them soils, topography, each parameter will be characterized by a single parameter.

Now, if you look at we discussed in previous lectures about watershed management and how through watershed management we can regulate, we can reduce the erosion also, water base erosion, wind erosion etc. Now, in those kinds of setup you can apply such kinds of models. There are of course, physically based model can also be used, you can also use mathematical models as well. But lumped models becomes quite useful for that kind of condition.

Distributed models. They consider the processes which are involved and they also consider the spatial variation. So, spatial variations are critically important in case of distributed models. What does this kind of model include or take as input parameter? Rainfall runoff, soil erosion, land use land cover changes, water quality, irrigation, water management studies, etc.

So, you see most of the models that till now I have discussed is one or other way capturing the phenomena, the interrelationships happening in nature with regard to one or other natural resources and that is why we are discussing these kinds of models in this lecture.

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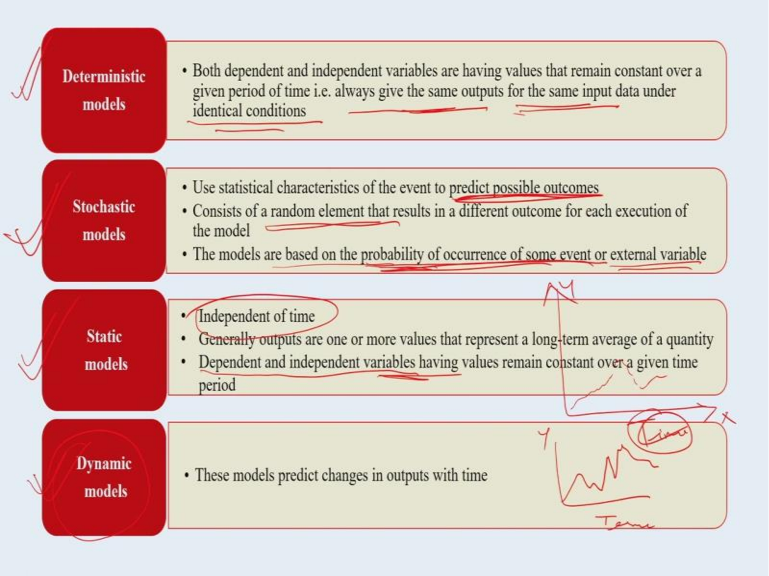

Deterministic model. Most of you might have heard about deterministic model, we use deterministic model quite frequently for various purposes, because what they consider, they consider both dependent and independent variable which generally have values that remain constant over a given period of time and that is why this always gives same kind of output for the same input under identical condition. Very, very important do note it that for same kind of input you will get same output in deterministic model provided that the other conditions are also same.

So, deterministic is very, very straightforward. And it is clear that for a given condition, for a set of input, if your input does not change, then your output also will not change. It will always give same kind of output.

Next Stochastic model, again often stochastic models are also being used. Now in case of stochastic model we use statistical characteristics of an event for what to predict possible outcome, say for rainfall. So, we know that if heavy rainfall takes place, there is a chance of flood. But the statistical characteristics of precipitation or rainfall through stochastic model will allow us to predict possible outcomes that could be a potential flood.

It also consists of random element that results in a different outcome for each execution of the model, they have random element, these type of models are generally based on the probability of occurrence of some event or external variable. See model to model there is slight differences and those differences one has to just remember.

So, here in stochastic model they are largely based on probability of occurrence of some event say rainfall, say for storm, any kind of say climatic weather event. So, the probability of rainfall occurrence this kind of event if you want to predict then stochastic models would help you.

Static model. For certain cases these kinds of models also become quite handy, static models naturally it is independent of time means, it will not change along the time. So, if your x axis is suppose time so with time there will be no change, independent of time. So, time unit or time a variable is actually almost meaningless here in the static models. Generally outputs are one or more values then represent a long term average of a quantity.

They are also dependent and independent variables, which will be having values which are constant over a given time period, they do not change. Dependent and independent variables some time they will be totally independent of time. So, when you want to analyze something or when you want to study or simulate any event as against time, then static models is not the right one to use.

Dynamic model. Now, these models predict changes in outputs with time. So, here in case of dynamic model, your time is a critical variable. So, with time there will be change. So, in that case, you have to use dynamic models, which always will capture along with the time variability in your observation in that particular system.

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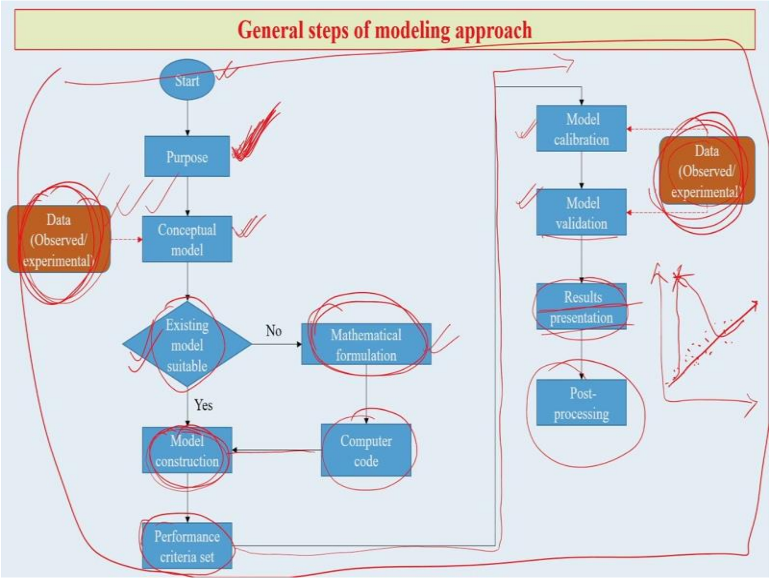

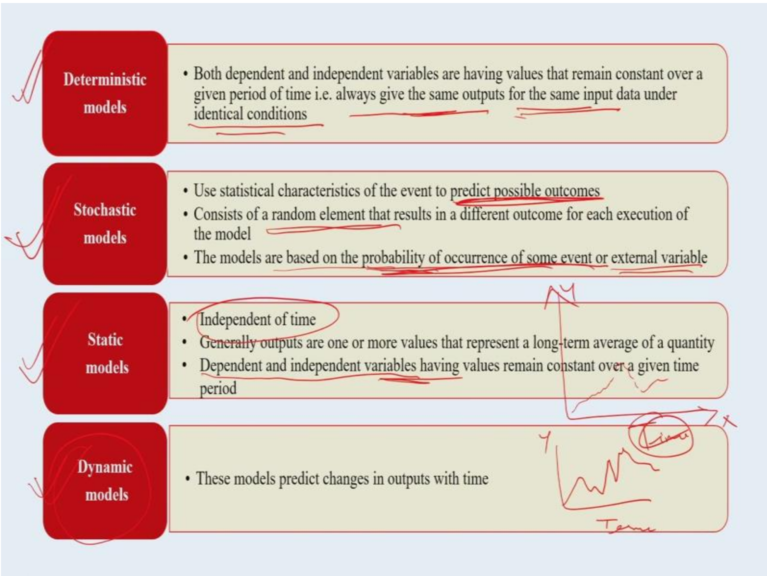

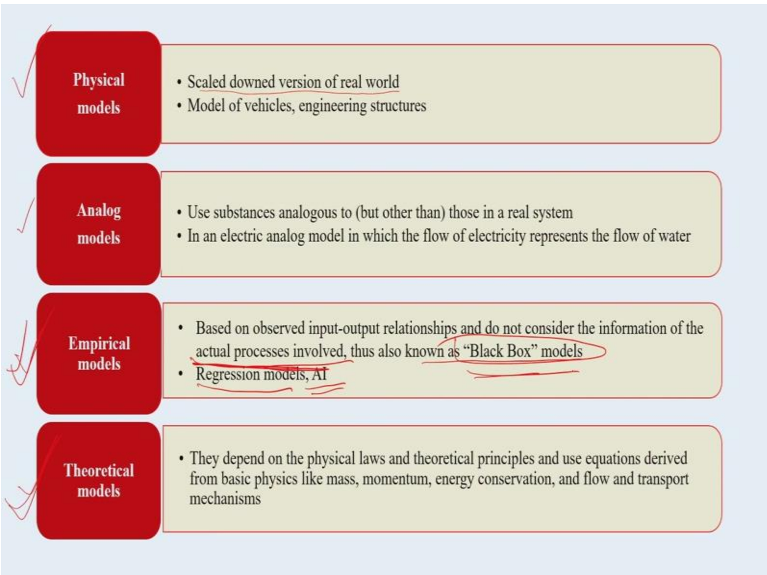

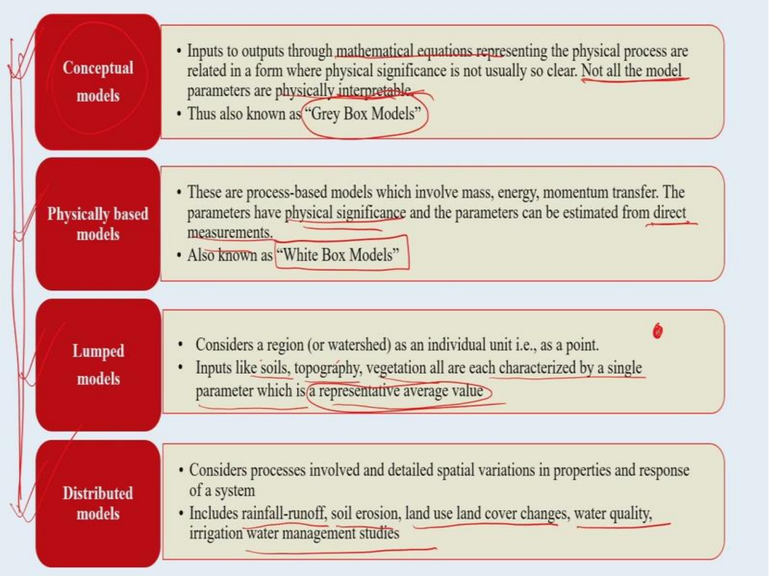

So, now, let us come to the general steps which we mostly follow in case of modeling approach. Various models already I have discussed with you and now, let us know that the general steps or approaches which most of those models that just we discussed around ten, eleven models, the basic framework or the basic skeleton of these modeling approaches, I will now just represent in front of you.

Now, you start any activity in the modeling exercise, you start with a purpose. We fix a purpose or goal or objective in mind first, before we go with the modeling exercise. Now, once the purpose is clear to us, then we try to find out that what kind of model or what kind of data will help us to analyze and to get some information about my purpose.

So, the next step is to find out a conceptual model and the associated data that you may be required. Because if you recall that at the very beginning I mentioned that simulation or modeling exercise will be robust only when you have good amount of data in your hand. Not only quality of data, but also the volume of data, quantity of data is also important for building a robust model. Means what, to get the region which is almost very close to nature. Now, once you have decided about a conceptual model and the necessary data that you may be requiring, then you try to see whether the existing any of the existing model which I just now discussed here different model sets or model right several, several model.

Now, what you are going to do is now try to find out whether among the existing model any one is fitting with regard to your purpose and also the available data sources. If it is no then you go for some mathematical formulation, you try to find out a different way. If it is yes, then use to go for model construction. If you have existing model which can explain or give or give some result for your purpose, then you go for model construction, and then you bring in your in our data, then you go for performance criteria setting, etc.

But if your existing models are not suitable for your purpose, then you try to figure out that how you can modify the existing model. That is first option. If you cannot, even after some modification you feel It is not possible, then you try to, you need to think something different. And that is the time when you need to find out your own programming some mathematical functions formulation, you have to insert into the existing model and try to see that if with your written new codes, whether you can able to construct the model in such a way that it could give you the result or it can fulfill your purposes.

So, once again repeat whenever a modeling exercise you will start, you start with a purpose. If purpose is clear, then you go for a conceptual model you try to build in your mind that this is the way the functions different functions will work and for these, I need this kind of data. So, you look for the data once these two things are clear.

Then we go for searching the existing model, whether any one of them are fitting with my purpose and if it does, then we go for straightaway for model construction and then we go for performance criteria setting. Once criteria is set, then we go for the function stage, which is model calibration. Very critical stage is calibration stage. Model calibration, you need a lot of data and next step once your model is calibrated, then we go for model validation. For model validation also you need data.

So, data if you have with you good amount of data then the exercise of modeling or simulations become much more easier. Once you validate your model after calibration then remains your model running and after your run you will get some results and that results within that model can give some output in the form of various graphics of various data sets.

Now, those you can present the way you wish. So, after you get the results those results directly as I said can be visible in your monitor and if it does not it comes just as a data then you have to process it, process it and then you go for either in table form or into figure forms whichever way you like to do and you can go also for some post processing of data. Sometime will happen is that in modeling result suppose for your data sets one or two datasets which are outlier, we know a outlier. So, suppose this this is the way your data distribution all data you are observing, one data is here. Now, if you consider these data, then your graph may go like this trend, but if you remove this one, then it could have gone straight line. So, post processing of your result or data which model will give you is also very very important for the ultimate term output presentation or result dissemination out of this modeling exercise.

So, this is the setup for modeling for any model, this is the general setup. Now, for any particular model there could be one or two other things also other function is also there. Suppose, if you few go for crop modeling, there will be crop parameters, if you go for water modeling, there will be various water parameters, for land if you go erosion model there will be some other parameters. So, on the basis of your purposes and model to model there will be some other functions or some other formulations in built into those models, but the basic structure as I discussed remain this.